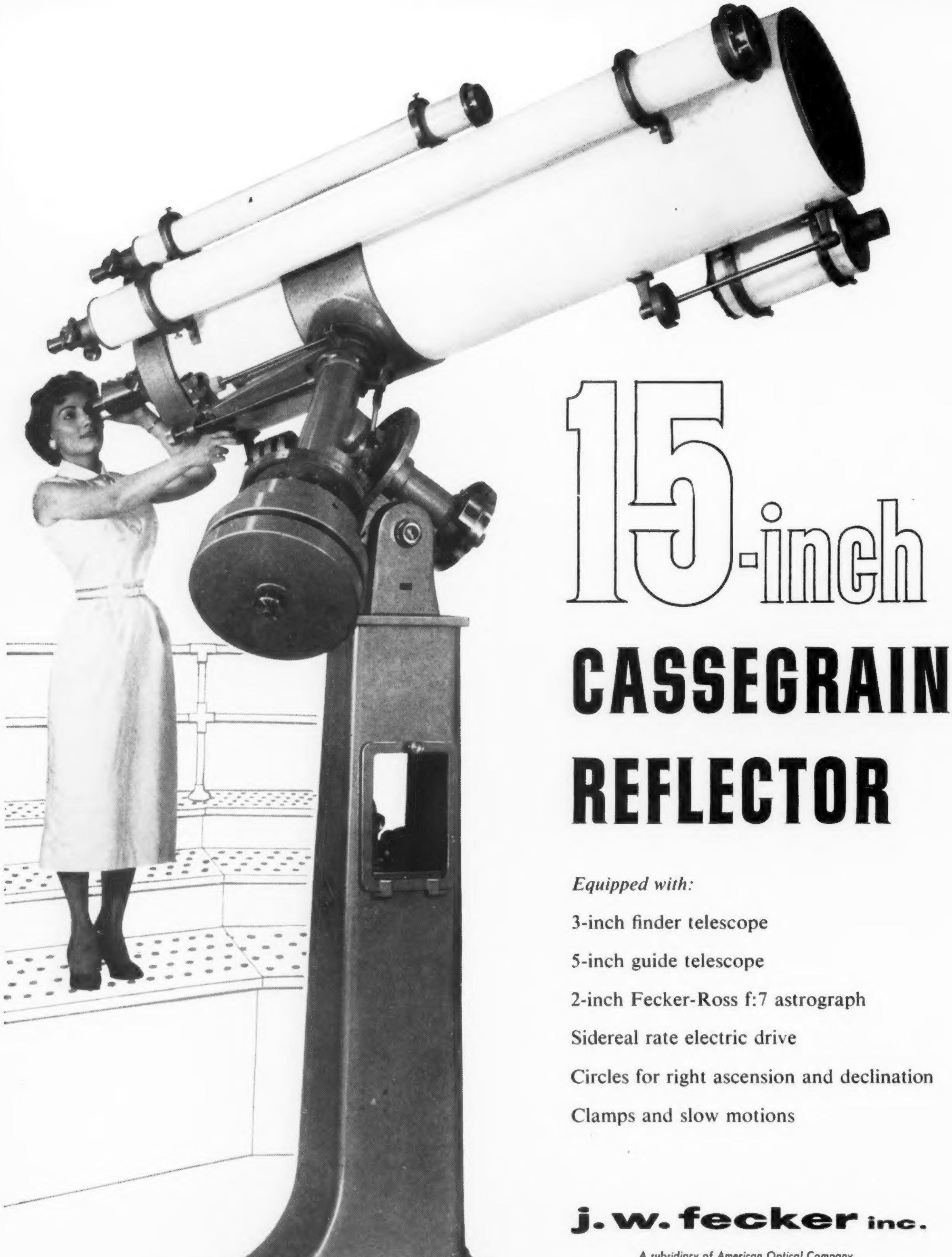
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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XVIII, No. 4 FEBRUARY, 1959

CONTENTS

COVER: The Atlas missile on its launching pad shortly before it was fired from Cape Canaveral, Florida, on the evening of December 18th, to become an artificial satellite. The men on the ground at the right are dwarfed by the 80-foot rocket. The large dark rectangular opening in the near side of the launching platform is the blast deflector to send the exceedingly hot exhaust gases into the water-filled trough in the foreground, where their heat is dissipated. U. S. Air Force photograph. (See page 196.)

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Solar Tower Telescope Planned for Kitt Peak

FOUR MILLION dollars have been allocated for a solar telescope at Kitt Peak Observatory in Arizona, to be several times larger than any instrument of this type in existence. More than 8½ million dollars have now been assigned to the National Astronomical Observatory by the National Science Foundation, including one million dollars for an access road to be built by the Bureau of Public Roads (SKY AND TELESCOPE, August, 1958, page 493).

At the top of its tower, the new instrument will have an 80-inch light-gathering flat mirror, while the image-forming mirror will be 60 inches in diameter, with a focal length of about 300 feet, twice that of the 150-foot tower telescope at Mount Wilson Observatory. The image of the sun in the focal plane will be very large — some 32 inches across.

Meanwhile, the 36-inch reflector for photoelectric work is being built by Boller and Chivens, South Pasadena, California, at a cost of $69,000. The building and dome for this instrument are contracted to Murray J. Shiff Construction Co., Tucson, for $112,700, with completion a year or 15 months in the future.

Kitt Peak astronomers are proceeding with plans for their 80-inch reflector. Sometime during the summer of 1959, Corning Glass Works, Corning, New York, is expected to deliver a pyrex mirror blank of this size for $115,000.

Construction operations on Kitt Peak have been awaiting Department of the Interior approval of the lease that the Papago Indians have given the National Science Foundation, in accordance with an act of Congress last August. The lease permits the rental of 2,400 acres for "as long as the land is used for astronomical study and research and related scientific purposes." The Papagos are receiving $25,000 for access rights to the site and 10 dollars per acre annually for about 200 acres to be developed at present. The rental of the protective perimeter area of 2,200 acres is at 25 cents per acre yearly. The Indians, noted for their basket weaving, will also have the right to use space on the site to sell their wares to the visiting public.

The observatory is being operated by AURA, Inc., an association of universities. Its present location is in rented space in Tucson, where land is being acquired for a permanent headquarters, to include office space, instrument, optical, and electronic shops. Inasmuch as Kitt Peak is only about a 50-mile drive from Tucson, it is expected that most of the scientific staff will live in the city.

Observation of a Volcanic Process on the Moon

NIKOLAI A. KOZYREV, *Crimean Astrophysical Observatory*

Translated by Luigi G. Jacchia

FOR MANY YEARS in the past, observers have reported possible changes on the moon's surface. Especially interesting among such reports are those of the appearance of haze that veiled details of the lunar craters. These visual observations, however, remained unconfirmed, since the visibility of such details depends strongly on the angle of illumination by the sun and possibly on the quality of the atmospheric seeing.

More objective evidence for such haze was obtained in October, 1956, by Dinsmore Alter, on a series of photographs of the craters Ptolemaeus, Alphonsus, and Arzachel, in blue and infrared light (*Publications* of the Astronomical Society of the Pacific, April, 1957, page 158). He used the 60-inch reflector of Mount Wilson Observatory.

This part of the lunar surface, located near the center of the disk, is very interesting because it contains a number of parallel fissures, which presumably came into existence after the formation of the craters. Due to the diffusion of light by the earth's atmosphere, all photographs in blue light are considerably less contrasty than are infrared ones. But the details on the floor of the crater Alphonsus appeared particularly washed out in Dr. Alter's photographs in blue light. I became convinced that this effect deserved serious attention and that on the floor of that crater there might occur an effusion of gases.

It should be understood at the outset that the washing-out effect cannot be caused by the diffusion of light in such gases on the moon. For this to occur, the layer would require a total density like that of the earth's atmosphere, that is, of the order of 10^{25} molecules per square centimeter of surface. But if the gases can be made fluorescent under the action of strong short-wave (hard) solar radiation, then for veiling to occur the gas need only absorb all such hard radiation of the sun. The coefficient of absorption will be very large for corpuscular, X-ray, and extreme ultraviolet solar energy.

Therefore, we might suppose that a layer of gas of the order of 10^{15} molecules per square centimeter – about 10^{-10} atmosphere – would have considerable fluorescence. The existence of such a localized "atmosphere" due to the effusion of gases from lunar craters seems entirely possible.

The question remains of whether the sun's short-wave energy is intense enough to produce fluorescent radiation in the visible part of the spectrum that could be seen against the background of the ordinary solar spectrum reflected by the moon. Incidentally, it should be noted that the Czech astronomer, F. Link, has argued in favor of fluorescence by minerals located on the surface of the moon.

Using spectral methods in 1955, I obtained some direct evidence for the existence of fluorescence in the ray system of the bright crater Aristarchus, reaching in violet light about 15 per cent of the ordinary reflected lunar light. This result, obtained by comparing the contours of the Fraunhofer lines of the solar spectrum and the reflected lunar spectrum, showed that it would be possible to attempt observing gas effusions on lunar crater floors.

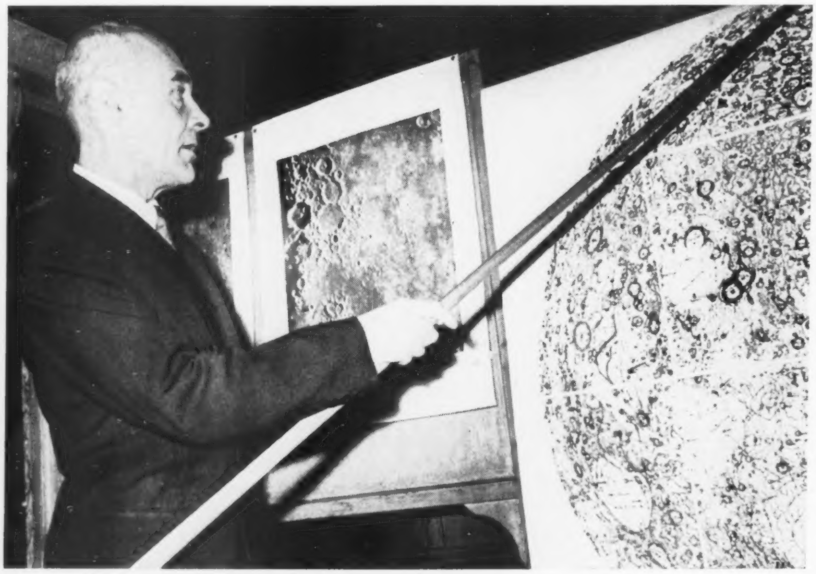
In October and November, 1958, together with V. I. Ezerski of the Kharkov Observatory, I was conducting spectral investigations of Mars, using the 50-inch reflector of the Crimean Observatory of the Academy of Sciences of the Soviet Union. At that same time, I decided to obtain systematically some photometrically standardized spectrograms of lunar details, in particular of the crater Alphonsus.

During these observations, the slit of the spectrograph was always oriented east-west on the sky. The linear dispersion was 23 angstroms per millimeter in the vicinity of the hydrogen-gamma line, and the scale of lunar details about 10 seconds of arc per millimeter. The normal exposure on Kodak 103a-F emulsion was 10 to 30 minutes.

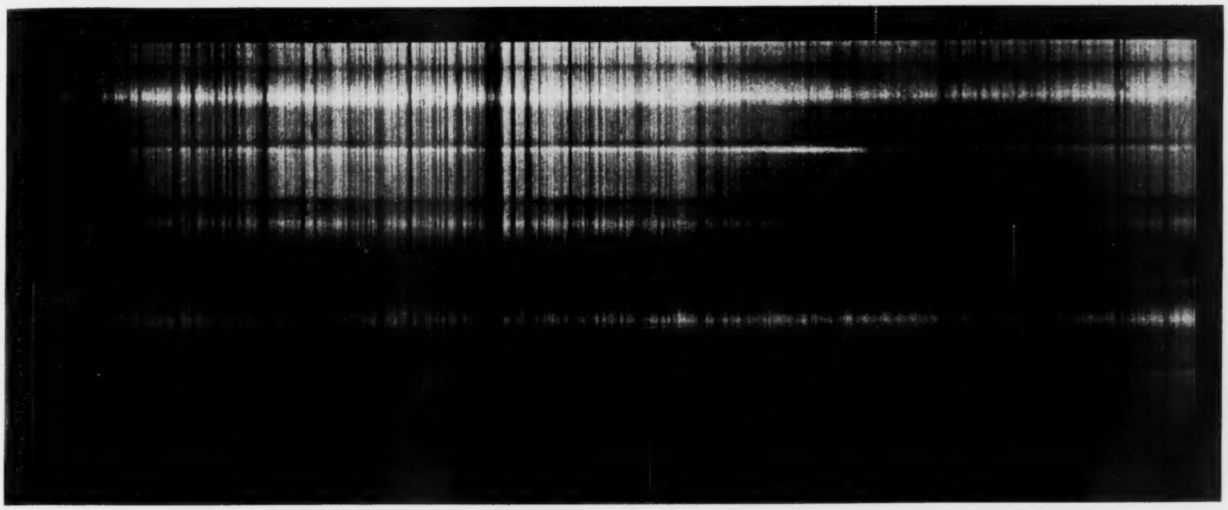
Nothing special was noticed on the spectrograms of Alphonsus up to the night of November 2-3, when three spectrograms were taken with the slit running through its central peak, as shown in the accompanying picture. While I was taking the first spectrogram, at 1^h Universal time, and guiding on the image of the central peak, the latter became strongly washed out and of an unusual reddish hue.

After taking this spectrogram, however, and in accordance with our program, we changed over to observe Mars, and the next spectrogram of Alphonsus was made from 3:00 to 3:30 UT, a 30-minute exposure. Only the central peak of this crater showed on the slit, and I was struck by its unusual brightness and whiteness at the time.

During the exposure I did not take my eye away from the guiding eyepiece, but suddenly I noticed that the brightness of



Announcement of the author's observation of activity on the moon aroused world-wide interest. Here Dr. Kozyrev is describing his work at a press conference at the Poulkovo Observatory on November 18, 1958. Photograph by Y. Shalamov, supplied by the U. S. S. R. Embassy, Washington, D. C.



The evidence that some kind of eruption occurred on the moon last November 3rd is contained in these two spectrograms taken early that morning. The upper one was an exposure from 3:00 to 3:30 Universal time, the other was from 3:30 to 3:40. Refer to the chart lower on this page to identify the absorption lines and to check the position of the strong emission originating very close to the central peak of Alphonsus. These bands, extending from 4737 angstroms toward shorter wave lengths, are conspicuous on the first spectrogram and absent from the second. The maximum brightness of this outburst may have gone unobserved earlier while Drs. Kozyrev and V. I. Ezerski were using the telescope to observe Mars instead of the moon. Both of these spectrograms were obtained with the 50-inch reflector of the Crimean Astrophysical Observatory.

the peak had fallen to its normal value. The spectrogram exposure was then immediately stopped and the following one was taken, from 3:30 to 3:40, with the same position of the slit.

I did not give serious thought to my visual impressions, believing that all the peculiarities I had noticed were caused by a change in the quality of the observing conditions. Therefore, it came somewhat as a surprise when development of the spectrograms showed that all the changes noted visually had in reality occurred on the central peak of Alphonsus.

On the first spectrogram (not reproduced), the central peak is considerably weakened in violet light compared with the neighboring details of the crater, a fact that was not observed on earlier spectra. Measurement of this photograph showed that the absorption varied inversely with the wave length, and the calculated general absorption turned out to be equal to 15 or 20 per cent in the visual region.

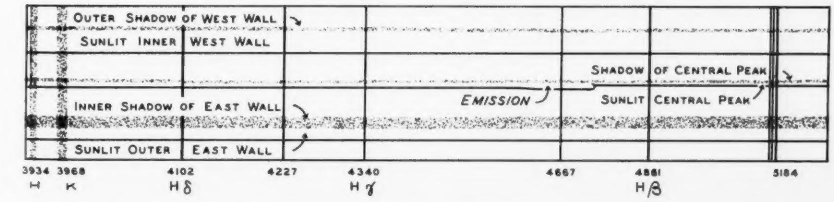
On the second spectrogram [the upper one at the top of this page] this absorption is not noticeable, and an emission spectrum stands out, composed of a series of broad bands superimposed on the usual spectrum of the central peak. Below this second spectrogram is reproduced the 10-minute spectrum that was taken immediately afterward, showing the normal appearance of the crater. Therefore, the phenomenon of gas effusion lasted not longer than $2\frac{1}{2}$ hours and not less than half an hour.

On the following night, November 3-4, I obtained two more spectra of Alphonsus, but its condition continued to be normal. Then the moon entered the last quarter phase and this region of its surface was in shadow and unobservable.

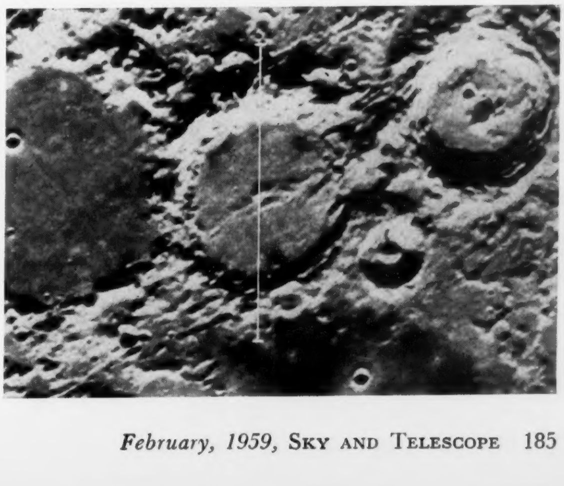
These observations are interpreted as showing that on the morning of November 3, 1958, there occurred a volcanic phenomenon. First there was an ejection of dust — volcanic ash (appearing reddish in the guiding eyepiece) — and afterward an efflux of gas (causing the emission spectrum). The effusion of gas could come from magma rising to the lunar surface.

The most noticeable peculiarity of the emission spectrum of the central peak is the group of bands starting at 4737 angstroms, sharply delimited on the long-wave side. These bands have 40 per cent of the normal luminosity of the peak in these wave lengths. But the emission is not superimposed directly on the peak, being slightly shifted away from the shadow, that is, toward the sun. This shift amounts to approximately 0.7 second of arc, or about $1\frac{1}{2}$ kilometers on the moon's surface. It can probably be explained by the sun's short-wave radiation penetrating only those parts of the gaseous layer that were nearest the sun.

One must presume that the shining of these gases was produced similarly to the luminescence of a comet, the solar radiation causing dissociation of the complex original molecules issuing from beneath the surface. Optically active mo-



The schematic diagram above is a key to the spectrograms at the top of this page. To the right, the position of the spectrograph slit during the observations is marked by the white line on this portion of a Lick Observatory photograph. Here Alphonsus is flanked by parts of the craters Arzachel, right, and Ptolemaeus, left. West is above, north to the left.



At the new Crimean Astrophysical Observatory, the dome in the left background contains the 50-inch telescope used by the author in his lunar observations. In the central building is a 16-inch photographic refractor, and right, a 20-inch Maksutov-type telescope. After destruction in World War II, the observatory was rebuilt at Partizanskoye in the southern Crimea.

lecular radicals were produced, which fogged the observable spectrum for a time. Such an effect could not, of course, occur on the dark side of the moon.

Photometric measurements of the spectrogram also indicate that the shadow of the central peak in the region of the bright bands is somewhat deeper than in other places along the spectrum outside these bands. From this, we can conclude that the optical depth of the gases in the observed emission was greater than unity and that the dimensions of the gaseous layer were not much smaller than those of the central peak, whose height is approximately 1.3 kilometers.

To obtain a full interpretation of the emission spectrum, it is necessary to analyze its intensity carefully, subtracting step by step from its observed intensity at each wave length the intensity of the neighboring part of the crater bottom. Such measurements require great precision and are not yet finished. But some information has already been obtained.

In the strong group of bands that start at 4737 angstroms, progressively weakening toward the violet, there appears as a very strong component the Swan band of the carbon molecule C_2. The distinct maximum at 4737 is the beginning of the vibrational band of this molecule. The presence of C_2 is confirmed by other considerably weaker groups of Swan bands, with maxima at 5165 and 5636 angstroms. The existence of the C_2 molecule in the effusing gases can therefore be considered as established.

In the region from the hydrogen-delta (Hδ) line to the H line of ionized calcium, there is a system of faint bands belonging to the linear molecule C_3, which is observed in the spectrum of comet heads just as the Swan bands are.

The Alphonsus spectrum differs from comet spectra, however, in the complete absence of the ultraviolet band of the CN molecule at 3883 angstroms. Comparatively bright bands exist in the spectrum from 4200 to 4600 angstroms and in other regions there are large numbers of faint bands. We have not yet succeeded in determining the molecules responsible for these bands. Furthermore, all the bands have a washed-out appearance. The Swan bands should be entirely sharp on the long-wave side, but they appear indistinct for about five to 10 angstroms, for some unknown reason.

It is possible that the observations just described will be unique for some time to come. But the existence today of internal energy and the possibility of orogenic processes (mountain formation) on the moon seem to have been established. The coincidence of the observed phenomenon with the position of the central peak can hardly have been accidental, and may indicate that the basic relief of the moon originated from within rather than from the impact of giant meteorites. The low thermal conductivity of the lunar surface layers may result from the porous character of volcanic material rather than from a dust layer.

EDITOR'S NOTE: Some new observational data can be added to those on page 123 of January, on the question of whether any lasting change has occurred in Alphonsus as a result of the phenomenon observed by Dr. Kozyrev. In *Circular* 405 of the British Astronomical Association, the red spot reported by H. P. Wilkins is said to have been photographed by G. A. Hole, Brighton, England, with a 24-inch reflector. On the other hand, a critical examination by J. Rösch with the 24-inch refractor of Pic du Midi Observatory showed neither structural nor color change. Letters from two experienced lunar observers with 12½-inch reflectors, Patrick Moore of East Grinstead, England, and Alika Herring of South Gate, California, report no visible changes, from examination under excellent seeing conditions on December 30th and 19th, respectively. The weight of the evidence appears to be against any permanent alteration in Alphonsus.

EFFECTIVE APERTURE OF THE HUMAN EYE

One of the most used of astronomical instruments is the observer's eye, for which the maximum aperture is the diameter of the pupil after the eye has become fully dark-adapted. In the British journal *Nature,* for November 29, 1958, three Czech scientists, V. Kadlecova, M. Peleska, and A. Vasko, report their study of the pupil diameters of 453 persons.

Each subject was kept in darkness for 15 minutes, and then the horizontal diameters of his pupils were measured in infrared illumination with the aid of an image converter, thus eliminating all effects of visible light.

For persons 30 years old, the maximum diameter to which the pupil can expand averages 6.5 millimeters (0.26 inch), but is greater for younger persons and less for older ones. It diminishes steadily from 7.5 millimeters at age 10, to four at 80.

The Making of the Barringer Meteorite Crater

OTTO STRUVE

Leuschner Observatory
University of California

This winter view of the Barringer crater, near Winslow, Arizona, was taken by Clyde Fisher from a commercial airliner. The great pit is the best-preserved terrestrial case of the impact crater of a large meteorite. American Museum of Natural History photographs on this page.

AMONG the most versatile astronomers today is Ernst J. Opik, formerly director of Tartu (Dorpat) Observatory in Estonia, and now for many years a staff member of Armagh Observatory in Northern Ireland. His numerous writings include a paper in the *Astrophysical Journal,* in which as early as 1922 he calculated the distance of the Andromeda galaxy as 1.5 million light-years – in good agreement with the best recent determinations – at a time when many astronomers still believed the spiral nebulae were inside our Milky Way system.

Meteors, however, have been Opik's favorite subject, and he has contributed new and stimulating ideas to the problem of the formation of meteorite craters on the earth and on the moon. His principal papers on this topic appeared in the 1936 *Publications* of the Tartu Observatory and in the *Irish Astronomical Journal* for March, 1958.

Basically, the problem is this: We can measure a meteorite crater to find its depth, diameter, rim height, and the probable mass of the shattered and dislodged rock. From these data we wish to determine the mass and velocity of the original meteoritic body. In the case of a lunar impact crater, this is all the information available. For a terrestrial crater, we may be able to collect some meteoritic debris, but this will represent only a minor fraction of the original mass. Only very small meteorites colliding with the atmosphere at low velocities retain any considerable portion of their masses, and Opik is not primarily interested in these small bodies. Rather he discusses, as a typical example, the meteorite whose impact caused the great Barringer crater in northern Arizona.

This crater has a diameter of about 1,200 meters, and the height of its rim varies from 36 to 49 meters above the surrounding plain. Since the crater floor is below the level of the plain, the walls are much higher within, but the floor itself is formed by fill resting on a base of solid rock 320 meters below the outside plain's level. From these dimensions, Opik computed in 1936 that the volume of rocky material shattered and ejected by the impact was 0.36 cubic kilometer, corresponding to a mass of 10^{15} grams or 10^9 tons.

Since fragments of shattered material are found at considerable distances from the crater, it could be estimated that the broken rocks were lifted to an average height of 1,200 meters or 1.2×10^5 centimeters. The work that is done in lifting one gram of this material is equal to the acceleration of gravity (980 centimeters per second per second) times the height, or approximately 10^8 ergs. The total amount of work done on 10^{15} grams would have been 10^{23} ergs.

Suppose the velocity of the incoming meteorite was 20 kilometers per second (2×10^6 centimeters per second). Then each gram of this body would have a kinetic energy of $\frac{1}{2}(2 \times 10^6)^2 = 2 \times 10^{12}$ ergs, and a meteorite weighing 5×10^{10} grams, or about 50,000 tons, would have a kinetic energy of 10^{23} ergs, sufficient to lift the shattered material and scatter it over a wide area. This meteorite mass would correspond to that of an iron sphere some 24 meters in diameter.

However, 50,000 tons represents only a *minimum* estimated mass, for the kinetic

The low exterior rim of Barringer crater is relatively inconspicuous, when seen in the distance from ground level on the surrounding desert. The crater's average diameter is four-fifths of a mile. Photograph by Clyde Fisher.

energy of the meteorite was expended in many ways besides lifting the shattered material. Heat was produced which vaporized much of the meteorite and melted some of the rock, and part of the kinetic energy was consumed in breaking the rock before it was lifted. Some of these effects must have required far more energy than the lifting did, and our problem is to find out how much more.

Most of the kinetic energy probably went into the generation of heat. Since the mechanical equivalent of heat is 4×10^7 ergs per calorie, each gram of meteorite would produce about $2 \times 10^{12}/4 \times 10^7$ or 50,000 calories. If we knew the entire amount of heat produced, we could estimate the total mass. However, this heat was dissipated within a few hours after impact, leaving little if any observable trace.

Instead, we must try to estimate the total mass of the meteorite from either its kinetic energy or its momentum (mass times velocity), and consider in detail what fraction of the energy was actually used in breaking and scattering rocks.

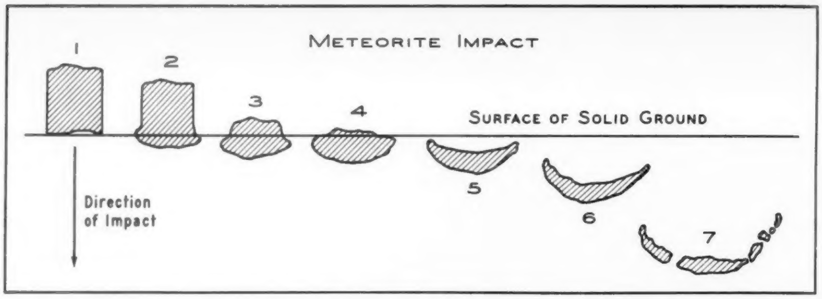
In his 1958 article, Opik sketches the sequence of events when a large meteorite collides with the earth, as shown here. He assumes that just before collision the body is a cylinder with a diameter equal to its height, and moving at 60 kilometers per second.

As the meteorite enters the surface layers of the earth, an enormous pressure is built up, which we can estimate from the formula

$$P = C\rho v^2,$$

in which P is the pressure in dynes per square centimeter, ρ the density of the rock, say 2.6 grams per cubic centimeter, and v is the velocity, 6×10^6 centimeters per second. The value of the coefficient C depends on the properties of the meteorite and the ground layers. We can expect it to be about $\frac{1}{2}$.

The pressure turns out to be 5×10^{13} dynes per square centimeter, or 50 million atmospheres. At such an enormous pressure all solids lose their rigidity and behave like liquids. This effect will cause the cylindrical meteorite to flatten out while it is penetrating the earth, as indicated by Opik in his sketches, and its



E. J. Opik's drawings indicate the probable sequence of changes as an initially cylindrical meteorite penetrates into the ground. Spreading horizontally, the body becomes a thin bowl that breaks into fragments. Adapted from the "Irish Astronomical Journal," for March, 1958.

radius will increase several times. As a result of this flattening, the depth of penetration is much less than it would be for a body of unchanging shape – on the order of only four original diameters of the meteorite instead of the 10 to 20 diameters that might be expected from the considerations of conventional ballistics.

Thus, the Armagh astronomer has calculated that the maximum depth to which the meteorite will penetrate is about seven times its original radius R, and it will have spread out to a radius of $3.6R$, for an impact velocity of 20 kilometers per second. If the impact is at 60 kilometers per second – a less probable value – the depth of penetration is about $8R$ and the final radius $4R$.

How far did the Barringer meteorite penetrate? As already mentioned, the depth to undamaged bedrock is about 320 meters. However, in his 1958 paper Opik points out that the depth of crushed rock will be about 25 per cent greater than the meteorite itself, which is preceded by a tremendous compressional wave. Also, the distribution of debris suggests that the meteorite did not fall vertically, but in a direction roughly 20 degrees from the zenith. Hence the actual distance of penetration of the meteorite was around 270 meters. Thus its original radius would have been 1/7 of this, or about 40 meters. As we are supposing the body to have been a cylinder of height $2R$, its volume would be $2\pi R^3$, or 4×10^{11} cubic centimeters.

The meteoritic fragments collected around the crater show that the original body consisted mainly of iron, and therefore had a density of about eight grams per cubic centimeter. Multiplying this density by the volume gives us the initial mass of the Barringer meteorite as 3.2×10^{12} grams, or about three million tons. Had we taken the velocity at impact as 60 kilometers per second instead of 20, the calculation would have given about two million tons. It is evident that the "minimum mass" of 50,000 tons, which we had obtained by considering the lifting of rock fragments, represents only about two per cent of the real mass.

Opik's precise manner of computing the motion during penetration is too complicated to be discussed here. But we can easily see in a qualitative way how his results were obtained by considering a simple analogy: the motion of a particle in a resisting fluid.

According to Newton's second law of motion, the force acting on a body is the product of its mass and acceleration. For a mass of one gram, the force of resistance would be equal to the acceleration but opposite in direction. Under certain conditions, the resistance is proportional to the velocity of the particle at each instant, becoming less as the particle slows down, so

$$\text{Acceleration} = -k \times \text{Velocity},$$

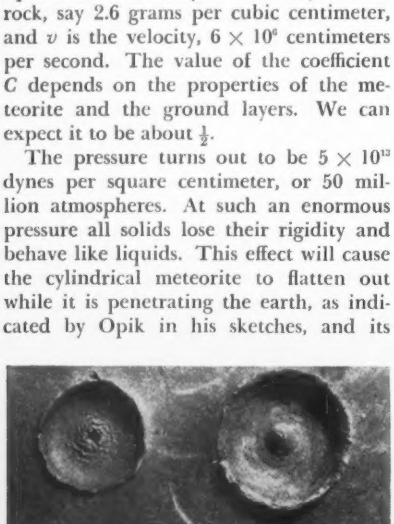
where k can be described as the coefficient of resistance of the fluid.

This equation can be solved mathematically to give the distance S to which the particle has penetrated:

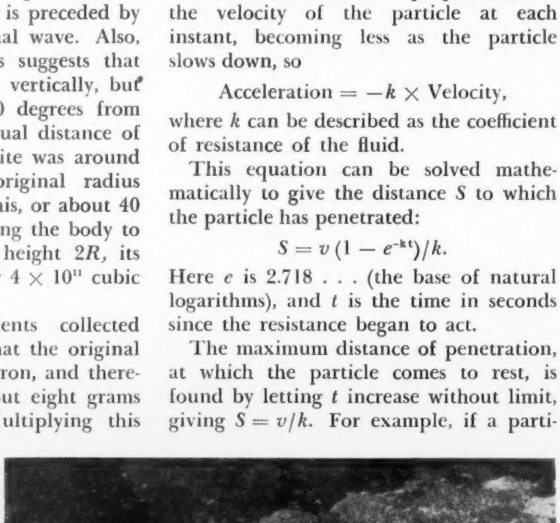
$$S = v\,(1 - e^{-kt})/k.$$

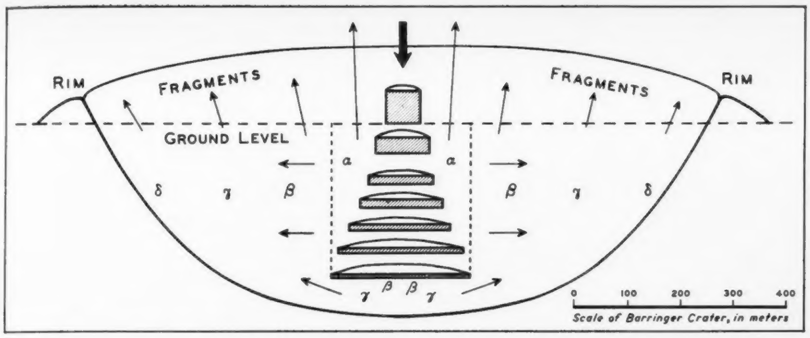
Here e is 2.718 . . . (the base of natural logarithms), and t is the time in seconds since the resistance began to act.

The maximum distance of penetration, at which the particle comes to rest, is found by letting t increase without limit, giving $S = v/k$. For example, if a parti-



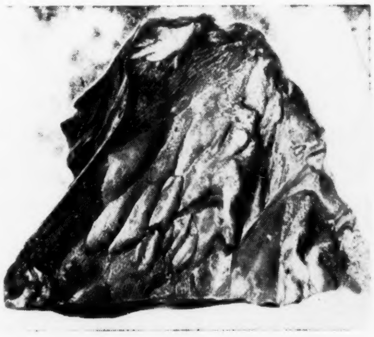
These laboratory craters were formed in steel plates by high-speed metal pellets with small cavities on their leading surfaces. See "Sky and Telescope," December, 1958, page 85, for a note on these University of Utah experiments. From the "Astrophysical Journal."





The formation of Barringer crater according to Opik is pictured schematically. As the meteorite penetrates the ground to the lowest position shown, the material α in the central cylinder is vaporized. The rock β is strongly heated and pulverized, γ reduced to rubble, and δ cracked into large fragments. Arrows indicate the motion of the debris. The heavy arrow shows the direction of the meteorite's impact. Adapted from the "Irish Astronomical Journal."

cle were initially moving at 6×10^6 centimeters per second, and assuming $k = 10^6$, the maximum distance of penetration would be six centimeters. Using the complete formula for the time 10^{-6} second after impact, we find that the same particle would have traveled 3.8 centimeters.



This nickel-iron meteorite was heated and streamlined by its flight through the earth's atmosphere. It is placed nose upward in this photograph.

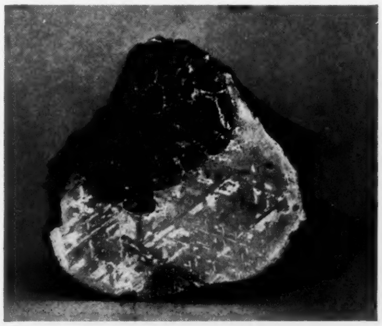
Our crude model gives numerical results that are actually not very different from those computed by Opik. For a cylindrical meteorite whose height is two centimeters and radius one centimeter, he finds a penetration to 4.5 centimeters in 10^{-6} second, and 7.9 centimeters in 2.6×10^{-4} second, by which time the penetration of the meteorite has practically ceased.

The coefficient k is not known for the material of the earth's surface. Moreover, it must depend on the crushing strength of the rocks, and on the shape of the projectile. (Consider, for instance, the difference in penetration by a hammer and by a pointed drill!) Although a meteorite may be assumed to be a blunt-ended cylinder, it is not easy to predict a suitable value of k. Opik's treatment of the problem depends essentially upon the transfer of momentum from the projectile to the earth, taking into account the densities of the meteorite and the rocks, and the crushing strength of the latter.

Since the meteorite expands sidewise during its motion through the earth, it generates pressure not only downward but at right angles to its trajectory. Opik has followed through the physical processes to deduce that, for an impact velocity of 20 kilometers per second, the mass of the meteorite should be 1/500 that of the crushed rock excavated from the crater. We have already noted that 10^9 tons of rocks were scattered by the impact. Multiplying this by 1/500 gives two million tons for the initial mass of the Barringer meteorite.

Opik's two different methods of calculation – from the depth of penetration and from the amount of crushed rock – give nearly the same result. Thus we may be fairly certain, as to order of magnitude, that the Barringer crater was caused by the fall at about 12 miles per second of a body of some two million tons, resembling an iron sphere 260 feet in diameter.

"Most of the mass of the meteorite must have become vaporized," remarks Opik, "or have backfired with cosmic velocity from the centre of impact, and cannot be expected to lie anywhere near the crater. The mass of the solid fragments collected from the surroundings of the Canyon Diablo [Barringer] crater is negligible, indeed, as compared with the estimated mass of the meteorite." Most of the meteoritic material, he suggests, was injected into the upper atmosphere, to be spread as fine dust over the whole surface of the earth by atmospheric currents.



A three-pound Barringer crater fragment that has been etched to show the Widmanstätten pattern typical of crystalline nickel-iron meteorites. This and the meteorite above are in the extensive collection of the American Museum-Hayden Planetarium.

QUESTIONS... FROM THE S+T MAILBAG

Q. To what part of the moon (or a planet) do the right ascension and declination co-ordinates of the object's position refer?

A. To the geometrical center of the disk, irrespective of any phase the body may exhibit.

Q. Why does Mars look so small in my telescope even with a magnification that should make it appear as large as the moon does to the naked eye?

A. This effect is due to seeing the planet's image in a restricted field of view, while the moon is observed against a large area of the sky. If you look at the moon through a long cardboard tube, it appears much smaller.

Q. How dense is the gas in interstellar space?

A. Its average density is about 10^{-24} gram per cubic centimeter. Since the gas is mainly hydrogen, this corresponds to about 10 atoms per cubic inch.

Q. How many variable stars are suitable for amateur observation in field glasses?

A. There are about 500 variables that are bright enough, and have a sufficiently wide range of magnitude variation, to be observed usefully in field glasses.

Q. What are the spectral types of the components of the double star Albireo (Beta Cygni)?

A. The 5th-magnitude companion has a type *B*9 spectrum. The 3rd-magnitude primary star has a composite spectrum, *K*0 and *A*0, indicating it is itself double, though too close to be separated in any existing telescope.

Q. For which of the planets other than the earth have detailed surface maps been drawn?

A. Such maps have been drawn for Mars and Mercury. In the cases of Venus, Jupiter, and Saturn, the solid surface is veiled from our view by clouds. Uranus, Neptune, and Pluto are too far away for detailed observations, and the first two of these are also cloud covered.

Q. What name is used for the study of the moon's surface?

A. The word is selenography, formed from the Greek *selene*, meaning moon.

W. E. S.

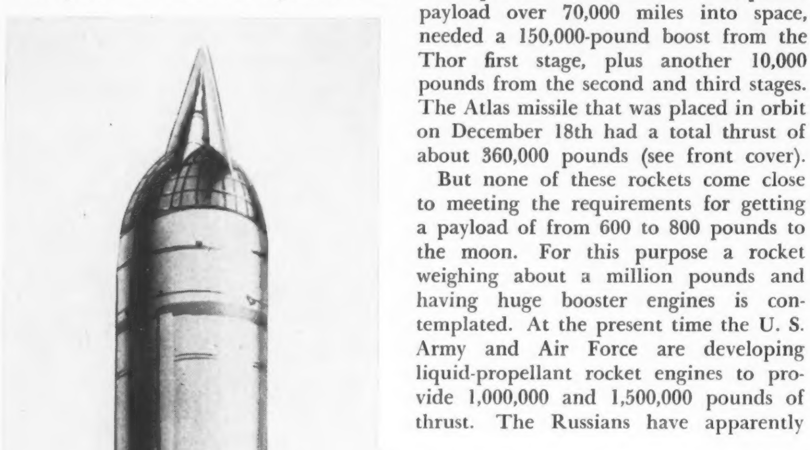
ROCKET PROPELLANTS—
The Key to Space Travel—I

FREDERICK I. ORDWAY, III, *General Astronautics Corporation*

DESPITE impressive recent advances in the rocket art, the task of getting a manned space vehicle onto the moon remains titanic. Expert opinion is divided whether improvements in conventional chemical propulsion systems will suffice, or whether radically new types will be needed to make travel to the moon and planets a reality.

To place the small three-pound Vanguard test satellite into orbit last March required a 27,000-pound thrust from the main stage of the rocket, plus second and third stages generating an additional thrust of over 10,000 pounds. The Explorer satellites relied on the 83,000-pound thrust of a Jupiter C, plus additional upper staging, to attain orbital velocity. The October, 1958, Pioneer lunar probe, which carried an 85-pound payload over 70,000 miles into space, needed a 150,000-pound boost from the Thor first stage, plus another 10,000 pounds from the second and third stages. The Atlas missile that was placed in orbit on December 18th had a total thrust of about 360,000 pounds (see front cover).

But none of these rockets come close to meeting the requirements for getting a payload of from 600 to 800 pounds to the moon. For this purpose a rocket weighing about a million pounds and having huge booster engines is contemplated. At the present time the U. S. Army and Air Force are developing liquid-propellant rocket engines to provide 1,000,000 and 1,500,000 pounds of thrust. The Russians have apparently solved this problem with their January 2nd launching of an artificial asteroid (see page 197).



An artist's drawing to show the size of missile that might be sent aloft with a million-pound-thrust engine, compared with the Atlas and Jupiter C. Single-chambered engines in the million-pound class, when practicable, could be combined in a cluster of six to produce six million pounds of thrust. Picture by Rocketdyne division of North American Aviation, Inc.

The present inadequacy of our rocket propulsion systems seriously limits the space-exploration missions that can be undertaken. To examine this problem, let us first recall some basic facts about standard rocket engines, as described in my articles in this magazine on page 48 of December, 1954, and page 88 of January, 1955.

Rocket	*Approx. weight in pounds*	*Approx. thrust in pounds*
Vanguard	22,600	27,000
Jupiter C	65,000	83,000
Pioneer/Thor	110,000	150,000
Sputnik-III launcher	185,000	260,000
Atlas	200,000	360,000
Titan	220,000	360,000

When the propellants — oxidizer and fuel — are burned in a combustion chamber, large quantities of hot gases are formed at high pressure. The heat energy of the chemical reaction is the power source. Because one end of the combustion chamber is open, the hot gases rush out through the nozzle exit, and the reaction to the force that accelerates the combustion products yields the thrust to propel the missile.

There are two basic ways of improving performance: increase the discharge velocity of the gaseous exhaust, and increase the mass of the material expelled in the exhaust. This is because the *momentum thrust* of the engine is the product of the exhaust velocity and the rate of propellant weight-flow. In the long run, increasing the exhaust velocities will be more important than increasing the mass, for the weight of the propellant would become enormous if very high missile speeds were to be achieved with the relatively low exhaust velocities that can be attained today.

First, let us consider a single-stage rocket, carrying a quantity of fuel that is ignited at the beginning of the flight and is completely used at the time of burnout. During this combustion period the missile is constantly accelerated, reaching its peak velocity at the moment of burnout. It is evident that the total mass of the exhaust propellant is of primary importance — the more of a par-

ticular fuel and oxidizer the rocket can carry the better it will perform.

We express this characteristic of a propulsion system as its *mass ratio* — the ratio of the fully fueled vehicle weight to its weight after all propellants have been expended. A high mass ratio is desirable, that is, we seek to get as much fuel in as light a frame as possible.

The maximum speed, v, that a single-stage rocket can attain is related to the mass ratio, M, and the exhaust velocity, c, by the expression:

$$v = c \log_e M,$$

where e is the base of natural logarithms, the number 2.718. . . .

For a missile to move with the speed of its own exhaust ($v = c$), $\log_e M$ must be 1, that is, the initial loaded weight has to be 2.718 times the empty weight. It also follows from the relation above that a missile can move faster than its own exhaust, if there is sufficient reaction mass available.

During the later years of World War II the 4.5-inch-diameter rocket was used by ground forces in Europe. Here a salvo of these solid-fuel missiles is being fired from projectors mounted on a $2\frac{1}{2}$-ton truck. U. S. Army photograph.

Engineering advances during the past decade have made possible larger and larger mass ratios. The first Viking rocket, for example, had a ratio of about 3.5, while Viking No. 12 had 4.5 or better. But we still have far to go. In order to make the maximum velocity of a rocket twice its exhaust speed, the mass ratio has to be 7.4, while for three times the exhaust speed the ratio becomes as large as 20. At present a mass ratio of eight or nine can be attained, but most missiles have values below this.

Suppose we had a fuel providing a specific impulse (defined later) of 350 pound-seconds per pound, which is better than now operationally obtainable, and we could secure an exhaust velocity of more than 10,000 miles per hour. We could then design a single-stage vehicle with a mass ratio of 7.4, which theoretically would go at twice its exhaust velocity. However, even this model would not escape permanently from the earth. The capabilities of single-stage rockets are definitely limited.

The Rheintochter III, shown in this captured German photograph, was a solid-fuel antiaircraft rocket launched from the ground. Radio-controlled and bursting to produce flak against Allied bombers, it never came into operational use during World War II. Picture released by U. S. Air Force.

The solution to this problem is multi-staging, used successfully in placing artificial satellites in orbit and in the recent lunar probe firings. The over-all mass ratio of a staged rocket is equal to the product of the mass ratios of the individual stages. Thus a three-stage missile, each component having a mass ratio of four, would have an effective ratio of $4 \times 4 \times 4 = 64$.

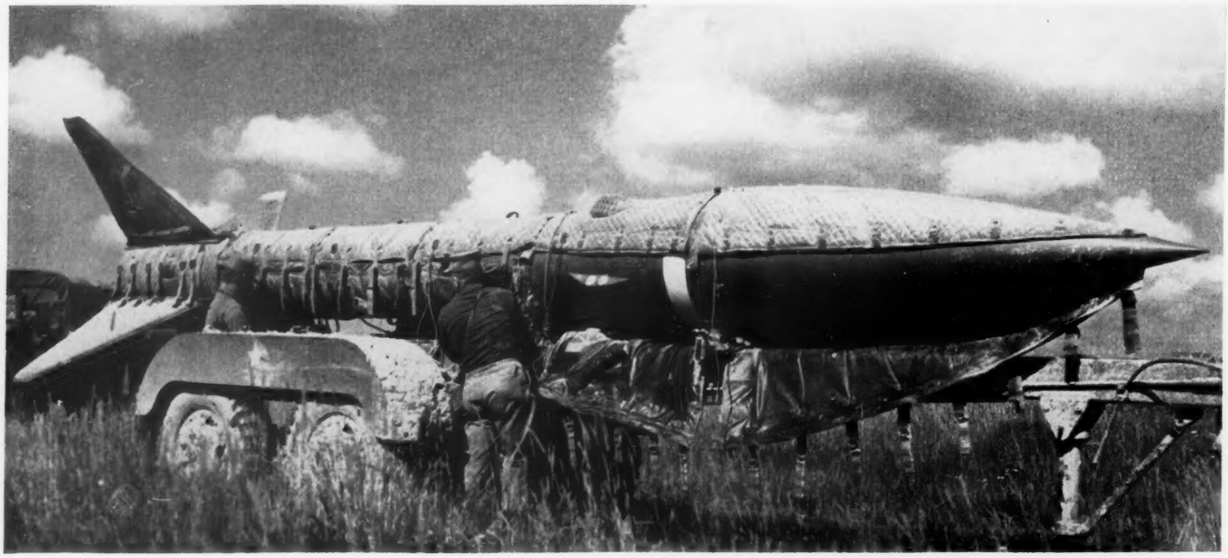
Whether we consider a one-stage or multi-stage vehicle, its performance will be governed largely by the energy available in its propellants, and by such design considerations as minimizing the weight that does not produce thrust. In comparing propellants, a useful concept is *specific impulse,* mentioned earlier. This is the impulse per unit mass of a propellant, expressed in units of pound-seconds per pound. It is an important number in many rocket calculations. For example, the final height reached by a missile is proportional to the square of the specific impulse.

For solid fuels, specific impulse is the product of thrust and time, divided by the mass of the propellant. For liquids, specific impulse is thrust divided by the weight-rate of propellant flow. While specific impulse is determined principally by the composition of the fuel, it also depends on the operating pressure in the combustion chamber, on the ratio of the nozzle exit area to throat area, and on the outside pressure. For instance, liquid oxygen and alcohol burned together provide a specific impulse of 260 if the pressure in the reaction chamber is 500 pounds per square inch, and 285 if the pressure is twice as great. The Vanguard rocket's first stage reportedly had a sea-level specific impulse of 252, the second stage 270, and third stage 260, the latter being values for the altitudes at which these stages fired.

To achieve spaceflight with chemical propellants, we need those that give the most energy per unit weight. Therefore, let us note some of the recent research in high-energy fuels, both solid and liquid.

Solid Fuels. Modern solid propellants give upwards of 200 pounds of thrust for each pound of fuel consumed per second but values above 240 are still rare. A few fuels do even better, Allegany Ballistics Laboratory reportedly having one that reaches 285. Although since World War II the specific impulse of typical solid fuels has increased by about 70 pound-seconds per pound, most experts feel that there is little hope of getting above 300, for stable solid chemical propellants contain rather limited energy. Some double-base and composite solid blends offer the best hopes of exceeding 250 pound-seconds per pound, but 245 represents the probable limit for standard carbon-hydrogen-oxygen-nitrogen types.

A few of the characteristics of a number of leading solid propellants are given on page 192. Ballistite is more than half nitrocellulose, 43 per cent nitroglycerin, and about three per cent diethylphthalate. Additional small quantities of other substances serve as flash depressors, aid in cooling the exhaust gases, absorb gaseous products of slow decomposition, prevent rapid thermal decomposition of



Thermostatically controlled heating pads are removed from the Honest John ground-to-ground rocket in preparation for firing. Solid-propellant motors of this type have been used as the first stage in Jason-type test missiles. U. S. Army photo.

unburned parts of the fuel, and so forth. The exhaust gases are about one-fourth carbon dioxide, one-fourth carbon monoxide, nearly 30 per cent water, about 15 per cent nitrogen, and five per cent hydrogen.

Ballistite can be safely stored at 120° Fahrenheit; its ignition temperature is 300° F., and its flame temperature is about 5,000° F. The cost of this material averages five dollars a pound, but the specific impulse of 210 and the exhaust velocity of nearly 7,000 feet per second are higher than those of the cheaper materials NDRC and Galcit. The exhaust velocities of the latter are 5,150 and 5,900 feet per second, respectively.

NDRC stands for National Defense Research Committee and is a composite propellant — fuel and oxidizer separate — consisting of about equal parts of ammonium picrate and sodium nitrate, and 10 per cent resinous binder, usually urea formaldehyde, though these ratios vary. It costs only about one dollar a pound, for a specific impulse of up to 180 pound-seconds per pound. The flame temperature is, however, only about 4,000° F., and the burning rate is relatively low.

Cordite consists of nitroglycerin, nitrocellulose, and carbamite, while Galcit is made of potassium perchlorate particles in asphalt and oil. The latest composites are usually made up of an organic poly-

CHARACTERISTICS OF SOLID PROPELLANTS

Combination	*Density*	*Flame Temperature*	*Specific Impulse*	*Burning Rate*	*Pressure Range*	*Exhaust Characteristics*
Amino ethanes (composite)	—	—	200	0.3-0.6	300-2,000	—
Ballistite (double base)	1.2-1.7	4,500-5,400	210	1.4	1,000-3,000	Black smoke, high flash
Black powder (composite)	1.2-2.1	3,600-5,400	70	0.1-0.5	100-1,000	Gray smoke
Buna and sulfo rubbers (composite)	—	—	210	0.4	100- 800	—
Cordite (double base)	—	—	180	—	1,000-3,000	Black smoke, high flash
Galcit 161 (composite)	1.8	3,600-4,500	190	1.6	1,300-3,700	White smoke
Lox-rubber (liquid-solid)	—	—	225	—	100- 500	Smokeless
NDRC-EJA (composite)	1.8	3,600-4,500	180	0.2-1.0	600-1,000	Gray smoke
Polymethane (composite)	—	—	215	—	500-2,000	—
WASAG DEGN (homogeneous)	—	—	182	0.2-0.8	700-4,000	Black smoke, high flash

Units: *Density,* water = 1; *Flame Temperature,* degrees Fahrenheit; *Specific Impulse,* pound-seconds per pound; *Burning Rate,* inches per second; *Pressure Range,* pounds per square inch.

JATO rockets (Jet-Assisted Take-Off) lift a U. S. Marine fighter plane from the ground with a mighty push. This solid-propellant device was developed during World War II to get planes into the air with heavier loads and from shorter runways. In this view, one of the rockets can be seen near the trailing edge of the near wing of the Vought Corsair F4U-4. Aerojet General Corp. photograph.

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Some solid fuels can provide exhaust velocities of from 4,000 to 8,000 miles per hour. The higher speeds, however, are generally from unstable fuels with undesirable physical or ballistic properties.

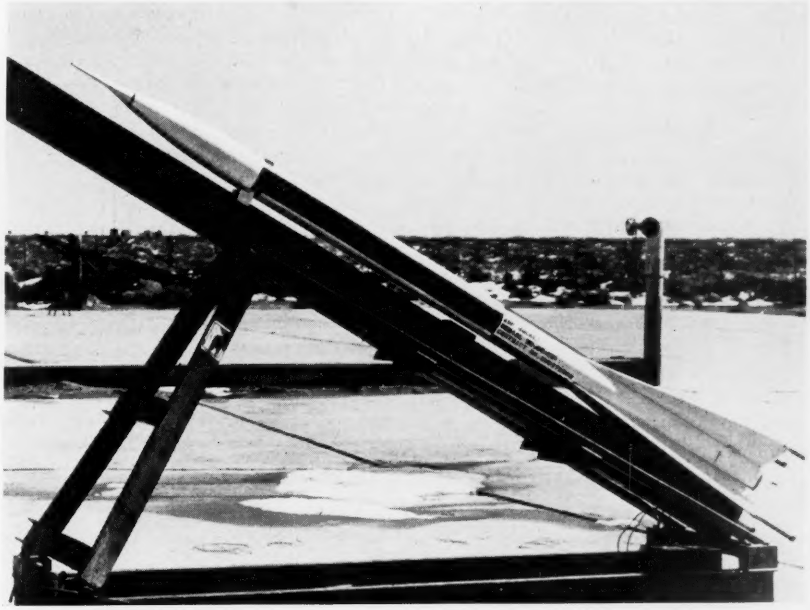
In the table, the burning rate refers to the speed at which the burning surface advances toward the head of the combustion chamber, and is often called the linear burning rate. It depends on the combustion pressure, the initial grain temperature, the velocity of gas flowing past the propellant surface, and the time from the instant of ignition. The burning rate tells the weight or amount of propellant consumed per second per square inch of burning area. Under a pressure of 2,000 pounds per square inch, most propellants burn at a rate of 0.2 to 2.0 inches per second. The burning rate increases by 0.05 to 0.2 per cent per degree rise in temperature.

One disadvantage of a solid rocket is that the propellant must be carried in the combustion chamber itself, and the size of the latter limits the amount of fuel. Liquid propellants, on the other hand, can be pumped in from a storage tank. But a small reduction in engine weight can often add more to missile velocity than can a relatively large improvement in specific impulse. Therefore, technical literature abounds with suggestions for saving weight in solid-fuel rocket engines.

The weight of the combustion chamber case can be reduced by pushing down chamber pressures, altering the geometry and composition of the solid charge, and restricting its burning surface. In case-bonded motors, the propellant forms an inner lining to the combustion chamber, adding strength to its wall. There is then no need for such inert components as propellant supports or thick insulation. Because the propellant helps insulate the walls, they can be made of thinner, lighter materials. Adding rubber to a case-bonded charge eliminates cracking and further reduces structural weight.

The Jet Propulsion Laboratory at California Institute of Technology has carried out valuable research on internally burning charges, offering nearly constant pressure and thrust. Combustion takes place on the surface of a longitudinal hole through the charge, gradually progressing outward toward the chamber wall, as illustrated in the diagram. Using an internally burning charge permits light, thin-walled construction in place of the heavy walls used earlier. Since the burning takes place on the inside, the combustion chamber is protected until this process has terminated.

There has been much improvement in extending the burning times of solid fuels. Restricted burning charges, in which the propellant charges are partially coated with an inhibitor to localize the burning surfaces, have been developed. Phillips Petroleum, Thiokol, and other firms report longer burning times for some of their larger units.



The Asp (Atmosphere Sounding Projectile) is a small solid-propellant rocket developed by the U. S. Navy for scientific exploration of the upper atmosphere. During the International Geophysical Year it was widely used to gather weather information and to measure cosmic radiation. The small radio transmitter for telemetering instrument readings is in the head of the rocket. For the total solar eclipse of October 12, 1958, in the South Pacific, five Asps were successfully flown for high-altitude observations of the phenomenon. They were in combination with Nike boosters, thereby attaining altitudes of up to 150 miles. Official U. S. Navy photograph.

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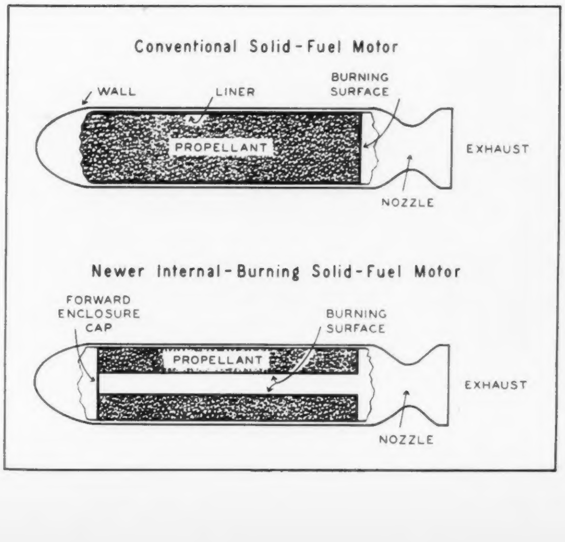
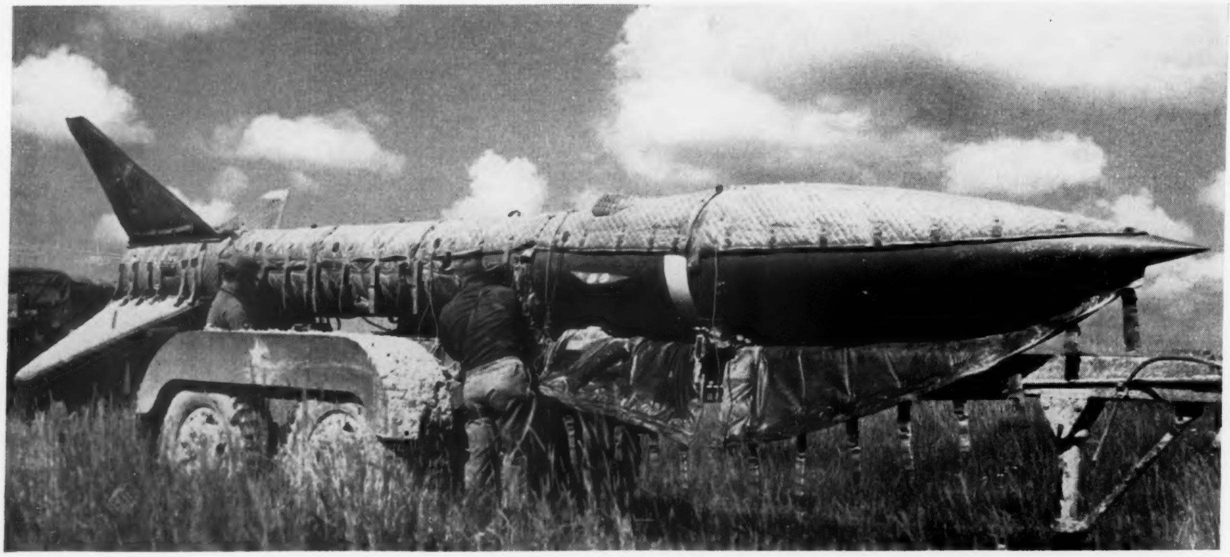
These rockets use an Honest John first-stage motor, Nike boosters in the second and third stages, a Recruit fourth stage, and a T-55 on top. The famed Far Side rocket, which probed at least 2,500 miles into space, had four Recruits in the first



A simplified diagram comparing the more recent and earlier types of solid-fuel motors. In the end-burning design, the heat of combustion spreads throughout the full diameter of the combustion chamber, requiring heavy insulation and thick walls. With the newer internal-burning design, the propellant itself protects and strengthens the chamber. The burning surface need not be cylindrical. Often several smaller burning tubes are used to obtain more rapid fuel consumption.



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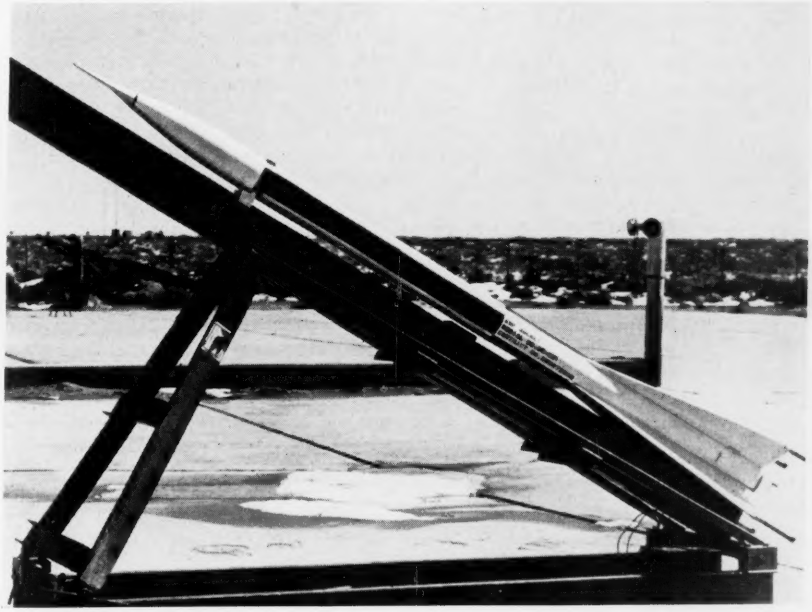

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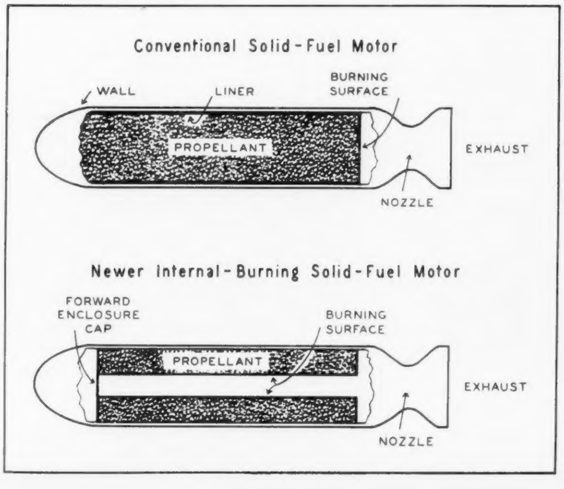

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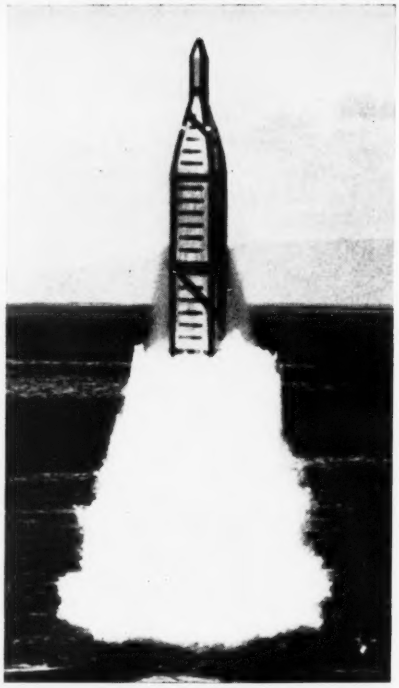
stage, one in the second, four Arrow II's in the third, and a single Arrow in the final stage. This balloon-launched rocket had an over-all weight of about a ton. While each Recruit rocket motor weighed only 350 pounds, a total thrust of some 35,000 pounds was generated — an excellent thrust-to-weight ratio.

Other solid-propellant rockets include the Air Force's X-17 three-stage reentry test vehicle and the Navy's Polaris fleet-test missile. The Polaris was designed to be fired from either submerged submarines or from surface ships. One reason for choosing a solid system is the hazard of handling liquid propellants on shipboard. This two-stage finless rocket is less than 30 feet long and is 54 inches in diameter. The first-stage thrust is believed to be about 130,000 pounds, but few performance data are available. To insure an accurate trajectory, the propellant burnout time must be precisely programmed, which hitherto has been considerably easier with liquid propellants.

Spaceflight enthusiasts have visualized the solid propellant primarily as an auxiliary power source — space-suit propulsion, vehicle attitude control, power-packs, ferry rocket propulsion, and planetary atmosphere sounding — but lately large rocket engines of this type have come into existence. Many technological improvements, such as those mentioned earlier, have done much to arouse enthusiasm for solid fuels, and their use in the upper staging of Explorer and Vanguard satellites and the October Pioneer lunar probe has served to remind us of their astronautical importance. The many advantages of solids over liquids — good mass ratios, ease of servicing, constant readiness, fast reaction time, low cost, reliability, stability in storage — may combine with rapidly improving performance to bring solid fuels nearly on a par with liquid ones.

The Minuteman ICBM, for example, is reported to be a three-stage missile with a Thiokol solid first stage, a Thiokol or Aerojet-General second stage, and an Aerojet-General third stage. Hercules Powder Company is currently looking into a new propellant for the third stage that would contain nitrocellulose and nitroglycerin combined into a homogeneous propellant. The Minuteman is to have a 5,500-mile range, and when developed will probably be used for some astronautical enterprises. It is considered to be a second generation ICBM, and will follow the liquid-powered Atlas and Titan missiles into operational inventory.



One of the newest solid-propellant missiles is the U. S. Navy's Polaris, under development as an intermediate-range weapon that can be launched from submerged submarines. Here a Polaris is seen rising from the waters of the Pacific, near San Clemente Island off southern California, during a test firing from an underwater launching tube. On December 30, 1958, in another partially successful test firing, the two stages of the rocket separated for the first time. Official U. S. Navy photograph.

A solid-fuel Sergeant rocket of the U. S. Army, with the chevrons of a master sergeant painted on its side, stands in firing position at White Sands Proving Ground, New Mexico. It is a surface-to-surface guided ballistic missile, developed by the Jet Propulsion Laboratory in co-operation with the Sperry Gyroscope Co. U. S. Army photograph.

The thrust of the Minuteman first stage is not publicly known, but the power of large modern solid-fuel rockets is indicated by the Army-sponsored Thiokol 450,000-pound motor recently tested in Huntsville, Alabama. Moreover, static tests of 300,000-pound-thrust solid units have been made on numerous occasions.

Despite spectacular advances in solid-fuel rocketry during the last few years, liquid fuels are preferred when very long distance flight is desired. Liquids can be carried in tanks outside the combustion chamber, which therefore can be made smaller and lighter; they have longer firing times; mixture ratio control and throttling are possible; and the energy released is higher than possible with solids. In our next installment we shall survey current advances in liquid-propellant technology, and take a look at some of the novel propulsion systems proposed for tomorrow's journeys into space.

(To be continued)

NEWS NOTES

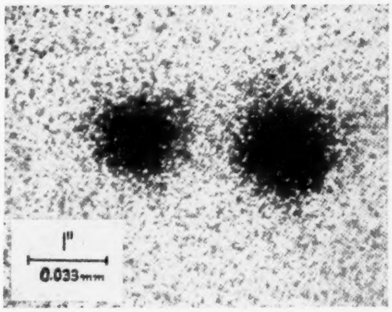
ZETA AQUARII

The well-known visual double star Zeta Aquarii consists of a pair of 4th-magnitude stars revolving around each other in about 600 years, with an average separation of four seconds of arc. It is located at right ascension $22^h\ 26^m.2$, declination $-0°\ 17'$ (1950 co-ordinates), just south of the celestial equator.

In 1942, K. A. Strand found that Zeta Aquarii also has a third component, detectable only by its periodic gravitational effects on the elliptical orbital motions of the visible pair. There has been some discussion whether the third body is a planet or a star. The true nature of this invisible member has now been determined by Otto Franz, U. S. Naval Observatory, who reports his results in the *Astronomical Journal* for September, 1958. This work was done when he was a staff member of Dearborn Observatory.

Dr. Franz reviewed the visual observations of Zeta Aquarii since its discovery by William Herschel in 1779, but the visual work was given much less weight than measurements made on 55 photographic plates taken with long-focus refracting telescopes. These were secured between 1914 and 1957 at seven observatories: Potsdam, Johannesburg, Lick, Sproul, Yerkes, Bosscha, and Dearborn. During this time, the separation of the visible components decreased from about three to two seconds of arc, while the position angle changed by about 40 degrees.

The photographic observations now cover the periastron part of the 25.5-year orbit of the invisible component, which revolves around the fainter star of the visible pair. The average distance of the invisible component from its primary is 0.39 second of arc, which corresponds to nine astronomical units at an adopted distance from us of 75 light-years. The invisible member turns out to have 3/10 the mass of the sun. Thus, although its orbit is about as large as Saturn's, it far outweighs that planet and is probably a star of about the 12th magnitude, which would be directly observable were it not so close to its primary. The masses of the visible components are 1.13 of the sun's for the brighter and 0.85 for the fainter.



The present separation of the visible components of Zeta Aquarii on plates taken at the prime focus of the 18-inch Dearborn Observatory refractor is less than 1/380 inch, but this is enough to allow accurate measurements of their relative positions. The scale represents one second of arc in this 400x enlargement, which is reproduced from the "Astronomical Journal."

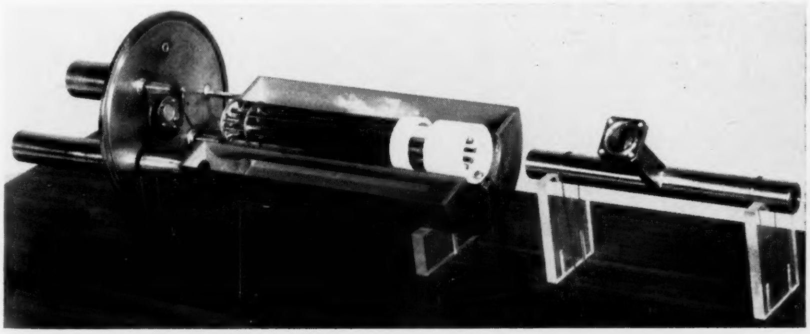
LABORATORY TEST OF RELATIVITY

According to Einstein's special theory of relativity, the velocity of light in a vacuum as measured by any observer is a constant, being independent of his motion or that of the source of radiation. The famous Michelson-Morley experiment was the first laboratory demonstration of this constancy. On September 20, 1958, a much more sensitive variant of this test was performed in New York City by physicists of Columbia University and International Business Machines' Watson Research Laboratory.

The new experiment employed microwaves instead of visible light. The heart of the equipment consisted of two masers, which are devices that amplify and re-emit microwaves (March, 1958, page 234). Into the cavity of each maser was directed a beam of ammonia molecules radiating microwaves at their natural frequency. The masers enabled extremely precise measurements of the frequency to be made, with an accuracy of one part in a trillion.

The two masers were arranged so that their ammonia beams pointed in opposite directions, east and west. After the radio frequencies were measured, the apparatus was rotated through 180 degrees, and the frequencies were remeasured. Thus the motion of the radio waves in either maser was in the same direction as the 18.5-mile-per-second movement of the earth around the sun in one case, and opposed to it in the other. If the velocity of the radio waves had been influenced by the earth's motion, the frequency would have changed by 20 cycles per second in each case. Instead, there was a difference of only one cycle per second, and this can be explained by disturbing effects of the earth's magnetic field.

This experiment showed that the change, if any, in the velocity of radiation was not more than 1/50 of the minimum detectable in previous tests, thereby confirming Einstein's conclusion.



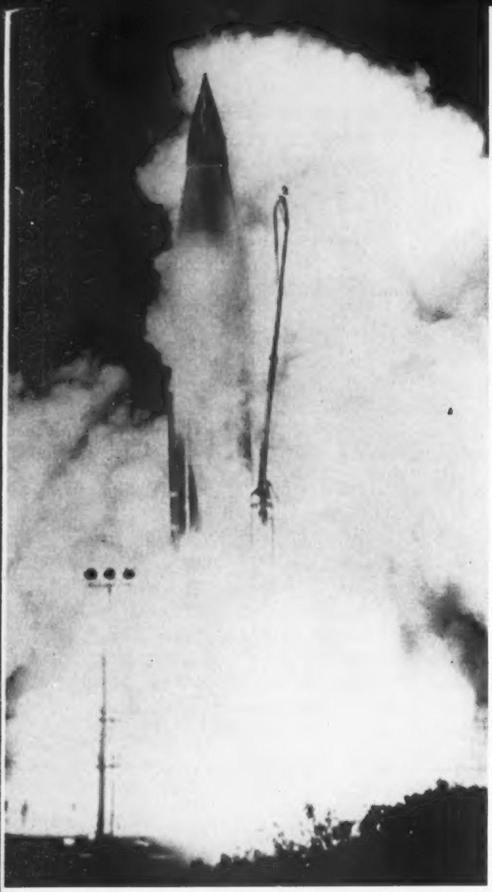
This cutaway view shows part of the apparatus used in the experiments at Columbia University. Ammonia molecules in two states of excitation are fed into the maser from the penny-sized disk in the plate at the left, which forms one end of an evacuated chamber containing the maser parts shown here. The molecules pass through the separator, in which those in the lower energy state are attracted to a cylinder formed by charged rods. The remaining molecules, all in the higher state of energy, pass into the resonant cavity at the right, where they produce a microwave signal of great purity at 24,000 megacycles per second. International Business Machines photograph.

IN THE CURRENT JOURNALS

IMPROVED SOLAR FLARE INDICATOR, by David Warshaw, *Radio-Electronics*, January, 1959. "This receiver, which detects solar flares by the SEA method (*S*udden *E*nhancement of *A*tmospherics), uses the first all-transistor circuit ever devised for this purpose. At present, the results obtained with these units are being carefully studied and coordinated by the American Association of Variable Star Observers (AAVSO) and the National Bureau of Standards."

NAVIGATIONAL REQUIREMENTS FOR THE RETURN TRIP FROM A SPACE VOYAGE, by Robert M. L. Baker, Jr., *Navigation*, Autumn, 1958. "We hope that through the employment of the safe and efficient braking-ellipse techniques such as those mentioned in this paper the space travel agents of the future will indeed be able to sell their clients round-trip tickets to the Moon and planets."

THE MASER, by James P. Gordon, *Scientific American*, December, 1958. "There are jobs to be done by all members of the maser family. In addition to simply telling time, ammonia and other gas-maser clocks will help explore some of the basic questions of physics."



This Air Force picture, released December 19th, shows the Atlas missile rising from its launching pad at Cape Canaveral, later to become an artificial satellite. It was fired by authority of the Advanced Research Projects Agency of the Department of Defense.

OBSERVING THE SATELLITES

Largest United States Artificial Satellite

PREVIOUS American satellites were dwarfed by the 8,750-pound Atlas B missile, about 80 feet long and nine feet in diameter, which went into orbit last December 18th. Its precisely controlled power plant, with the addition of more stages, may be able to carry large instrument payloads and even a man into space.

The new satellite, 1958ζ, was launched southeastward from Cape Canaveral, Florida, at 23:02 Universal time. The initial period of its rapidly changing orbit was about 101.5 minutes. During Zeta's first circuits of the earth, it rose to an apogee height of about 911 miles and sank to 118 miles at perigee, according to Space Track, the orbit-computing division of the Air Force Cambridge Research Center.

At an orbital inclination of 32.4 degrees, the Atlas rocket could pass only over places within that latitude north or south of the earth's equator. Presumably so low an inclination was chosen to facilitate the communication experiments, which required that it remain as long as possible within the range of ground stations in the southern parts of the United States. This same consideration may also have dictated the choice of the initial perigee point, placing the satellite low in its orbit as it passed these stations.

As early as 1946, a project had begun that later evolved into the Atlas program, and since 1954 development of this intercontinental ballistic missile (ICBM) carried a very high Air Force priority. The Atlas missile, 10th in the B series, was designed and built by Convair, a division of General Dynamics Corp. The rocket motors were developed by the Rocketdyne division of North American Aviation, Inc.

During the extensive preflight tests of the assembled Atlas 10-B, necessary to insure the proper operation of some 40,000 components, the interior of the vehicle was filled with gas under high pressure to prevent buckling of the thin-walled shell.

At the time of launching, the Atlas weighed about 122 tons. During the first two minutes of flight, added power came from two boosters which fell away. The longer-burning sustainer motor operated for a total of $4\frac{1}{2}$ minutes from the moment of firing.

As the vehicle rose in powered flight, a new and improved guidance system was in operation. The Atlas carried inertial guidance detectors, which telemetered information to a ground-based digital computer. This was linked to a command radio network that controlled the vernier rockets on the vehicle. Thus, the motion of the rocket could be altered to meet the actual circumstances of its flight, whereas the earlier American satellites had relied on preset programming.

During its first circuits of the earth, the Atlas was tracked principally by its radio transmissions, rather than by optical means. A network of stations used Microlock receivers to pick up the transmissions at 107.94 and 107.97 megacycles. Simultaneous triangulation from several stations, measuring the Doppler effect of the satellite's motion, allowed very quick determination of the approximate orbital elements. Radar observations were obtained from stations as far north as Bedford and Millstone Hill, both in Massachusetts. The first photographs were secured by the Baker-Nunn tracking camera at Woomera, Australia, on December 19th at 16:34 and 18:23 UT, during successive passages of the satellite over that part of the world.

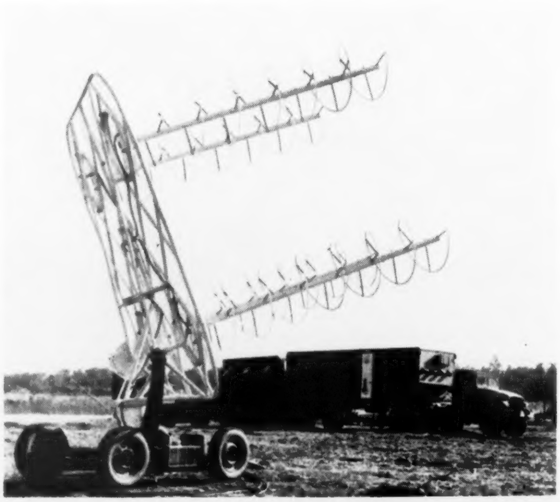
Visual observations of the tumbling of the Atlas satellite have been reported to Project Rotor by G. N. Walker and his associates at Bloemfontein, South Africa. On December 21st they observed a recurring brightness cycle of 63 seconds, each maximum of light intensity being double, with peaks about five seconds apart.

However, the flashing behavior was quite different on January 3rd, when the Atlas was seen from Cambridge, Massachusetts, by Moonwatch observers. Although the rocket was some 1,200 miles away, it periodically attained an apparent magnitude of -1. If enough observations of the flashes have been made during the short life of this satellite, their interpretation may be simpler than for the Russian satellites, because the shape and dimensions of the Atlas are known.

With the Atlas in orbit, even though for an estimated life of only about a month, two types of communications experiments were carried out. In the first, a tape-recorded message (from President Eisenhower) was transmitted to ground stations whenever a command to make such transmission was sent to the satellite. Rebroadcast, the message was heard by millions of people in all parts of the world.

In the second series of experiments, messages were radioed to the satellite, both in voice form and as seven multiplex messages in telegraphic code. The messages were stored in the satellite, to be retransmitted later upon command from the ground stations.

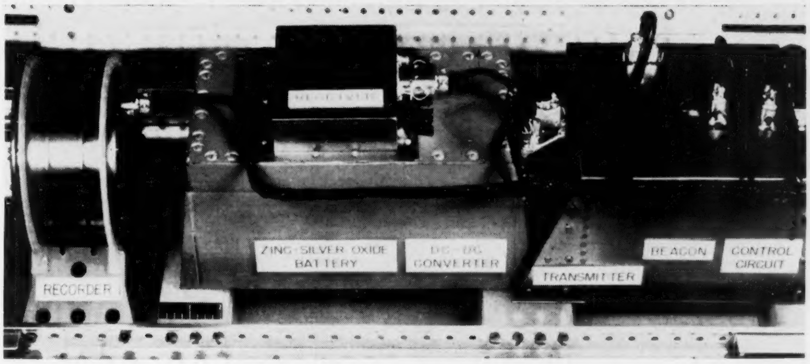
These experiments are an important



The helical antenna array of one of the portable U. S. Army ground stations. Many of these units took part in a series of communication experiments with the orbiting Atlas missile. The picture shows the adjustable mount which is operated by remote control from the van in the background. U. S. Army photograph.

advance in the use of ultra-high frequency (UHF) for long-distance radio communication. It has the great advantage over longer wave lengths of being less subject to atmospheric disturbances, but UHF can be used only for line-of-sight transmission, because it penetrates the earth's ionosphere instead of being reflected from it.

Other astronomical bodies have already been used to relay radio messages around the curve of the earth. Canadian scientists have successfully employed reflections from meteor trails (SKY AND TELESCOPE, October, 1956, page 541) and experiments are under way with the moon as a reflector (see February, 1958, page 178).



Communications relay equipment was installed in the Atlas missile. The equipment, which used an 8-watt transmitter powered by zinc-silver-oxide batteries, was designed to receive, store, and relay messages from ground stations. The total weight of the communications payload, including a second transmitter, receiver, recorder, and the antennas, was about 150 pounds. U. S. Army photograph supplied by the Department of Defense.

RUSSIAN SPACE PROBE IN ORBIT AROUND SUN

A TINY ASTEROID is now moving around the sun with a period of 450 days in an orbit slightly larger than the earth's. This novel astronomical object is a man-made vehicle carrying instrumentation, although its radio transmitters are no longer in operation.

There are some reasons for believing that the primary objective of the Soviet probe launched on January 2, 1959, was to place such an asteroid in orbit. The main scientific results, however, were obtained in the vicinity of the moon, as the probe passed within 5,000 miles of our largest satellite. The technical achievement of sending so heavy a rocket so close to the moon, thence into an orbit around the sun, is most impressive.

The last stage of the vehicle weighed 3,245 pounds. Its payload of about 795 pounds contained instruments for measuring the moon's magnetic field and radioactivity, for studying cosmic ray intensity in interplanetary space, for detecting heavy nuclei in cosmic rays, for measuring corpuscular radiation from the sun, and for recording meteorite impacts.

One novel feature of the Soviet probe, intended to permit it to be briefly observable by optical means, was the ejection of a cloud of luminous sodium vapor. This was released at 00:57 UT on January 3rd, when the probe was some 75,000 miles from the earth. Lasting about five minutes, the yellow sodium glow is known to have been photographed from Alma Ata, in Soviet central Asia. It could not be observed from the United States, where the constellation of Virgo in which the probe was then located had not yet risen.

The radio transmitters sent back to earth the instrument readings on four frequencies (in code form decipherable by Soviet scientists), and one of these frequencies, 183.6 megacycles, was used for tracking the space probe. After $2\frac{1}{2}$ days, the batteries ran out of power, but during that time the Russian probe may well have provided the most significant set of data yet obtained from a vehicle in space.

As this account is being prepared, only incomplete and sometimes contradictory data are available concerning the path of the new asteroid. Its closest approach to the moon occurred at 2:59 UT on January 4th. The velocity at that time was 2.45 kilometers a second relative to the earth, too great to permit capture by the moon as a circumlunar satellite, and therefore the rocket continued to recede from the earth.

While it was still relatively near to us, the probe's path was a hyperbola with respect to our planet, since at any point its speed was greater than the corresponding velocity of escape from earth. Later, when it had receded so far from the earth that the sun's gravitational attraction was predominant, the probe entered into an elliptical orbit around the sun.

Preliminary calculations showed that the orbit is an ellipse with an eccentricity of about 0.148, the distance from the sun varying from 91 to 122.5 million miles. Perihelion was to be passed on January 14, 1959. Because the period of orbital motion is 1.23 years (450 days), the artificial asteroid will next come to the earth's vicinity about $5\frac{1}{2}$ years from now. This synodic period is long because the period of revolution of the asteroid is so nearly that of the earth, and the motion of the two bodies relative to one another is slow. The heliocentric longitude of the object's perihelion is probably 117°; the earth's perihelion is at 102°.

Provided the orbit becomes well enough known to permit accurate predictions for future oppositions, the tiny object may be bright enough for direct observations with very large telescopes. While it was receding from the earth, the artificial asteroid may have been photographed by Mount Wilson and Palomar Observatories, on January 5th at 12:00 UT, as a 16th- or 17th-magnitude object near the Virgo-Libra boundary. However, the identification of the moving object observed was ambiguous, as possibly it was a faint ordinary asteroid, far from opposition. The question must await further photographic measurements of the object's position.

At the time of the California observation, the Russian space vehicle was about 400,000 miles from the earth. Doubling the distance would make the object $1\frac{1}{2}$ magnitudes fainter, if its phase remained the same.

The plane of the probe's solar orbit practically coincides with that of the earth's orbit. Thus it is possible that the Soviet space probe may eventually collide with the earth, perhaps many centuries from now. In this event it would surely perish in the earth's atmosphere like a spectacular fireball.

What should be the scientific name by which this new object will be known? Pending approval by the International Astronomical Union, F. L. Whipple, director of Smithsonian Astrophysical Observatory, has proposed "artificial planet 1." Writing in *Harvard Announcement Card* 1421, he suggests that future man-made objects that go into orbit around the sun be given similar names, the number to indicate the order of launching date.

Eventually there will be cases of the rediscovery of lost artificial planets. As Dr. Whipple points out, each such object would for a while be indistinguishable from a natural asteroid, and so would receive a temporary designation of the same kind as astronomers now use for newly found asteroids (1958 AA, for example).

The significance of the Soviet accomplishment in sending so large a rocket carrier into space is self-evident. It is true that this was not the first man-made object to escape permanently from the earth (see page 201), and that last year two American Pioneers had initial velocities only a few per cent lower than that of the Russian final-stage rocket. But the first stage must have had a tremendous initial thrust — estimated at upwards of half a million pounds — an outstanding feat of engineering.

MARSHALL MELIN
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The Poulkovo Observatory and three of its most famous directors are on these Russian stamps. The blue and black stamp at the left, issued in 1954 to publicize the restoration of the observatory, spans a century of astronomy at Poulkovo. From left to right are F. A. Bredichin, 1831-1904; F. G. W. Struve, 1793-1864; and A. A. Belopolski, 1854-1934. The Russian government spent large sums to erect, equip, and staff the Poulkovo Observatory. Dedicated in 1839, it was the world's leading observatory for some time and the first to have a large staff and a systematic program of operation. F. G. W. Struve, its founder and first director, was a pioneer astronomer in obtaining reliable measurements of stellar distances. Many years ago, the distinguished American astronomer, Simon Newcomb, described Poulkovo Observatory as "the astronomical capital of the world." Bredichin appears again on the sepia and ultramarine stamp at the right, issued in 1956 to commemorate the 125th anniversary of his birth.

Some Astronomical Stamps—II

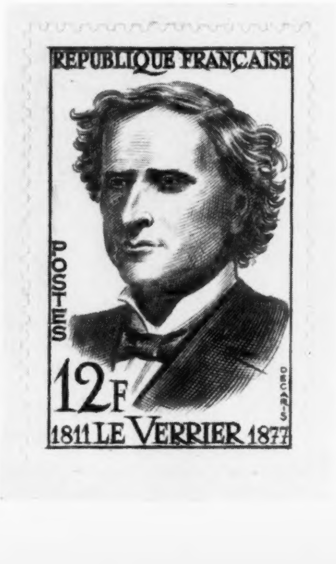
Alphonse P. Mayernik

THE SECOND PART of my collection of recent astronomical stamps portrays some famous astronomers who worked between the last years of the 18th century and the present. These men's ideas, observations, and calculations helped bring about the explosive growth of astronomy now in progress.

The two Russian stamps honor one of the world's leading observatories, Poulkovo, near Leningrad, and have portraits of three of its most famous directors. They were Friedrich Georg Wilhelm Struve, Fyodor Alexandrovich Bredichin, and Aristarch Apolonovich Belopolski. Struve, founder of Poulkovo, was its first director (1839-1861). He was prominent for his work on double stars and on stellar statistics. Bredichin, also on the second Russian stamp, was director from 1901 to 1904, being well known for his researches on comets and meteors. Belopolski, director from 1919 to 1934, was a pioneer in observational astrophysics.

The six French stamps testify to France's prominence in mathematical astronomy. Lagrange's work provided tools used in many branches of astronomy today. Laplace, often remembered for his nebular hypothesis of the origin of the solar system, made a more basic contribution in his great treatise on celestial motions. Leverrier was another French astronomer with exceptional mathematical

Three prominent French astronomer-mathematicians are portrayed on these three stamps of France. Above left: Marquis Pierre Simon de Laplace is on a rose-brown, 30 + 9-franc stamp of 1955. His "Mecanique Celeste" is a classic work on solar-system motions. Left: On an 8-franc violet-blue and blue-green stamp of 1958 is Joseph Louis Lagrange, whose discussion of the three-body problem is important today. Right: Urbain Jean Joseph Leverrier is shown on a 12-franc sepia and gray stamp issued in 1958. His calculations leading to the discovery of Neptune were a striking demonstration of the power of mathematics in astronomical problems.



On this deep green stamp, a 10-pfennig issue of West Germany, is a portrait of the famous German mathematician whose methods of orbit calculation are used to this day. Carl Friedrich Gauss was also an inventor of non-Euclidean geometry, foreshadowing the basis for Einstein's theory of relativity.

In 1936 Czechoslovakia put out this violet-colored stamp, of 60-haleru denomination, in honor of General Milan Stefanik, 1880-1919. Although known primarily as a Czech patriot, he was educated as an astronomer.

ability. For many years director of Paris Observatory, he greatly advanced the understanding of the planets' orbital movements.

Although he was primarily a physicist, Foucault's name is well known to every astronomer. His famous pendulum experiment of 1851 gave a dramatic demonstration of the earth's rotation. He introduced the knife-edge method of mirror testing known by his name, and was one of the first to use silver-coated glass mirrors in reflecting telescopes.

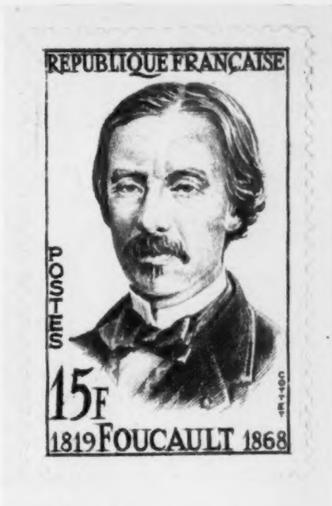
Henri Poincaré was a mathematician of extraordinary genius, who illuminated many of the most difficult problems in astronomy. He contributed fundamentally to celestial mechanics, and to the intricate problem of the stability of rotating fluid masses. An account of his work in stellar astronomy appeared in SKY AND TELESCOPE, March, 1958, page 226. Flammarion, the most recent astronomer to appear on a French stamp, was the best popularizer of astronomy who ever lived, and was the founder of amateur astronomy in France.

Gauss, who is pictured on a West German stamp of 1955, was the outstanding German astronomer and mathematician of the early 19th century. He devised methods for computing elliptic orbits for comets or asteroids from three observations, and he introduced the method of least squares, which for the first time made feasible the efficient analysis of observational data on a large scale.

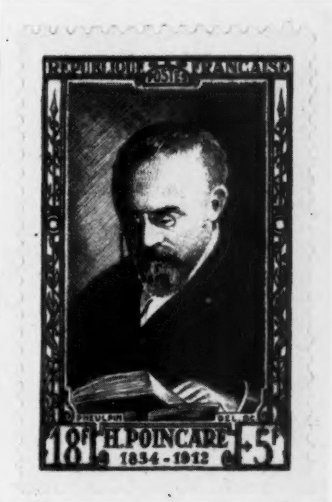
The Czechoslovak stamp honors the memory of General Stefanik, who is best known to history as a founder of Czechoslovakia as a nation in 1918, becoming its first minister of war. An astronomer by training, he lived from 1906 to World War I as a political exile in Paris, where he was secretary of the Société Astronomique de France and influential among amateur astronomers.

This month's selection concludes with Albert Einstein, on a stamp of Israel issued shortly after his death in 1955. Einstein is regarded by many as the greatest theoretical physicist since Newton. His theory of relativity successfully explained astronomical phenomena (the bending of light in a gravitational field, the abnormal motion of Mercury's perihelion) that could not be accounted for by Newtonian gravitational theory.

(To be continued)

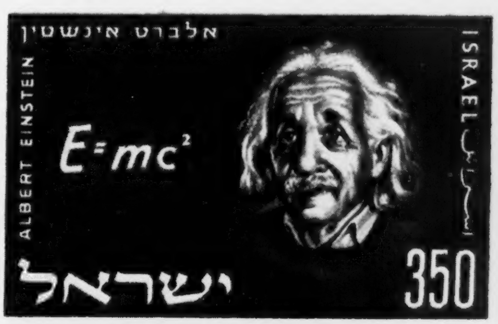


Jean Bernard Leon Foucault, originator of the Foucault test, is honored on a slate and green French stamp of 1955.



Henri Poincare, French astronomer and mathematician, on a dark brown semi-postal issue of 1952, for 18 + 5 francs.

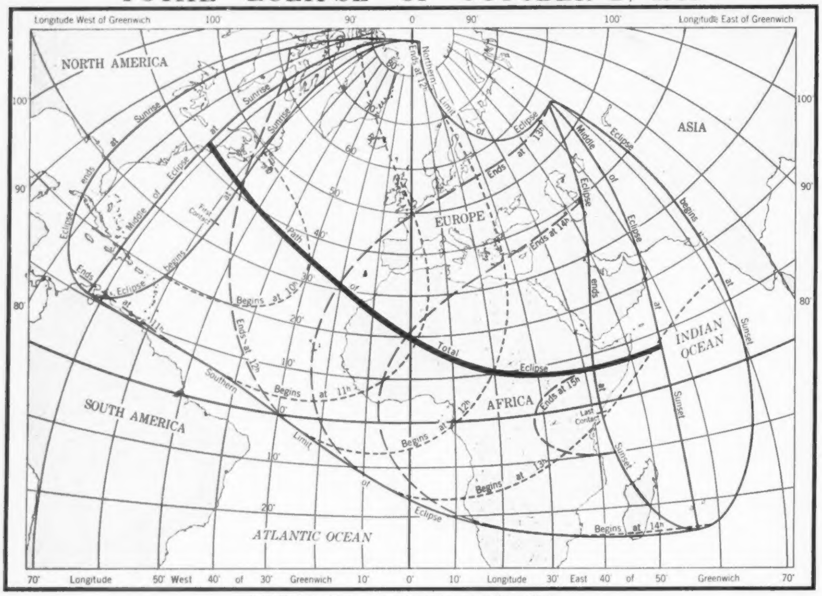
This 18-franc ultramarine stamp of 1955 shows the French astronomer and author Camille Flammarion, whose Juvisy Observatory, founded in 1883, is also seen. He began the French Astronomical Society in 1887.



An Israeli issue of 1956 (350 pruta, dark brown) honors Albert Einstein, 1879-1955, a theoretical physicist and philosopher. His special and general theories of relativity profoundly altered our concepts of the universe.

The Next Total Solar Eclipse

TOTAL ECLIPSE OF OCTOBER 2, 1959



NOTE: The hours of beginning and ending are expressed in Universal Time

The general circumstances of this fall's solar eclipse are indicated in this map reproduced from the 1959 "American Ephemeris and Nautical Almanac," with the path of totality shown by the heavy line. The most favorable locations for eclipse expeditions are probably in the Canary Islands, which the eastward-moving central shadow of the moon crosses just before reaching the western coast of Africa. The eclipse ends in the Indian Ocean at sunset.

ASTRONOMERS in easternmost North America, Europe, and Africa, are circling Friday, October 2, 1959, on their calendars. It is the date of the last of this year's three eclipses, and the only total one of the sun, the others being a lunar eclipse on March 24th and an annular solar one on April 8th.

The maximum duration of totality for the October eclipse will be three minutes and two seconds. The sun will be wholly covered by the moon for watchers in a narrow strip extending from Massachusetts across the Atlantic to the Canary Islands, thence through the Sahara desert, the Sudan, and Ethiopia, ending in the Indian Ocean. Outside this ribbon, observers will see the sun partly eclipsed over a vast area reaching from Greenland to the Caribbean, and from Michigan to Pakistan.

In the eastern United States, the sun will rise already in eclipse. At New York City the end of the partial eclipse comes 57 minutes after sunrise; at Cleveland, Ohio, 24 minutes; and at Ann Arbor, Michigan, only 16 minutes. At Toronto, Canada, this interval is 36 minutes; at Atlanta, Georgia, a scant nine minutes. From this it is clear that visibility of the phenomenon will be better the farther north and east the observer is located.

Next October's eclipse will be visible as total from the North American continent only in a very limited area, which nevertheless includes the thickly populated neighborhood of Boston, Massachusetts. The middle line of the path of totality begins in central Massachusetts and reaches the Atlantic Ocean near Salem, where the sun's disk will be blotted out for about 55 seconds. Even at this relatively favorable location, the lower edge of the sun will appear only about one degree above the horizon when totality begins at 6:50 a.m., Eastern daylight time.

At the Atlantic coast, the path of totality extends nearly due east, and is about 38 miles wide. The southern limit runs through Framingham and Quincy, Massachusetts, and the northern border a few miles north of Nashua, New Hampshire, and near Haverhill, Massachusetts. The western end of this zone, where the middle of totality is just at sunrise, lies a little west of Gardner, Massachusetts.

Inside the region thus delimited, mid-totality occurs within a few seconds of 5:50:20 a.m. Eastern standard time at points along the central line, and about 12 seconds earlier at the southern limit or later at the northern one.

Anyone in that area who hopes for a view of the startling phenomena of totality must be careful to select an observing site with an unobstructed view of the eastern horizon. Because of the low altitude, the silvery corona will be greatly dimmed by the extreme thickness of atmosphere through which it must be viewed.

Much more suitable circumstances for eclipse observations will occur in the Canary Islands, a Spanish possession near the coast of northwest Africa. The zone of totality is there about 67 miles wide, and its central line passes some 10 miles

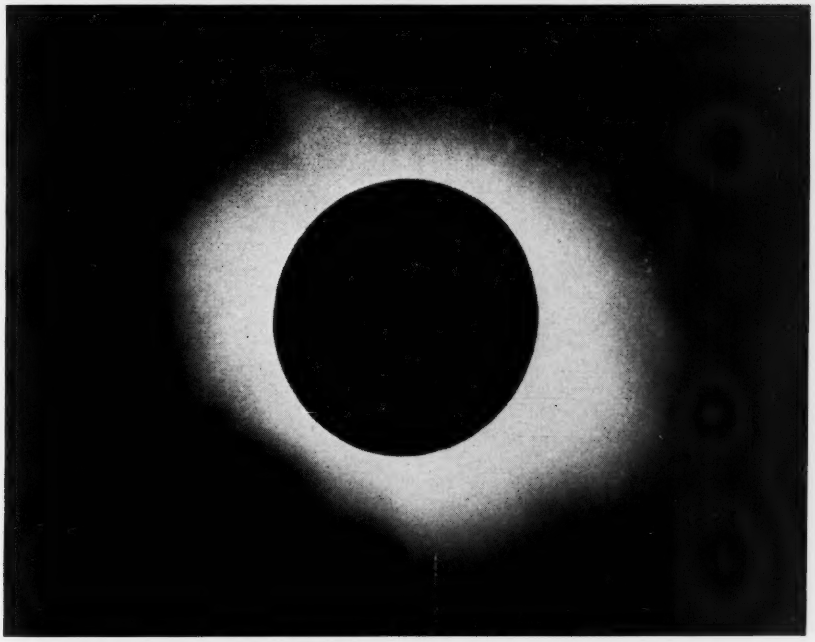
Observers within the area that is shaded on this map will be able to view the sun's corona on October 2nd. This includes the most densely populated part of New England, with the central line of the moon's shadow reaching the coast at Salem and Marblehead, Massachusetts. Throughout the entire region charted here, the closing stages of partial eclipse will be observable. Based on data from "Circular" No. 78 of the U. S. Naval Observatory.

north of the northern point of the island of Tenerife, and about 13 miles from the northern extremity of neighboring Gran Canaria. On both of these islands, mid-eclipse comes within a few minutes of 10:40 a.m., local time, with the sun's altitude about 54 degrees, and totality lasts about 2½ minutes.

Tenerife is a well-known tourist resort, with many facilities for visitors. According to information about eclipse sites collected by Prof. H. von Klüber, of Cambridge, England, the most suitable location for an expedition may be the geophysical station now under construction at Las Mesas, a hill near Santa Cruz de Tenerife. Farther south from the central line are many places suitable for eclipse camps. Detailed information concerning Tenerife and other islands of the Canary group has been collected by J. M. Torroja, of Madrid Observatory, in *Publication* No. 2 of the National Astronomy Commission. This pamphlet in the Spanish language contains a summary of the expected weather conditions. The best forecast for any part of the Canaries is for south Fuerteventura, where there is a desert climate similar to that of the nearby African coast.

Probably most of the scientific expeditions to the October 2nd eclipse will go to the Canary Islands. On the mainland, in the Spanish colony of Rio de Oro, the one settlement very near the central line is the military station Aiun, to which access may be difficult. In French Equatorial Africa, near Lake Tchad, Ft. Lamy is practically on the central line, in longitude 15° 03′ east, latitude 12° 10′ north, and totality will last for about 156 seconds. This isolated point is accessible by all-weather roads and by several commercial airlines.

The foregoing information about observing conditions in the Canary Islands and Africa is from a report distributed by Commission 13 of the International Astronomical Union. U. S. Naval Observatory *Circular* No. 78, published July 3, 1957, contains detailed predictions for the path of the total phase in the United States.



When the moon blots out the main body of the sun during totality, the outermost solar atmosphere — the silver-gray corona — becomes briefly visible. On October 12, 1958, from the path of totality in Chile, M. Valdez took this picture of the last total eclipse previous to the coming spectacle.

LETTERS

Sir:

Recent attempts to put Pioneer vehicles in orbit around the moon have obscured the fact that man-made objects had been sent into interplanetary space a year earlier. On October 16, 1957, at 10:05 p.m. Mountain standard time, an Aerobee rocket was fired from Holloman Air Force Base in New Mexico. At a height of 85 kilometers, explosives in its tip were detonated to eject very-high-speed metallic and metal-oxide pellets — artificial meteors (SKY AND TELESCOPE, January, 1958, page 111).

Three luminous jets from this explosion were observed from Sacramento Peak, from Palomar Observatory, and from several stations between these locations. From this the initial directions could be determined, as well as the space velocity of the brightest one. This was upward, at over 15 kilometers per second — greater than the velocity of escape from the earth. The brightness of this body, apparent magnitude −2 from Sacramento Peak, shows that it was about one centimeter in diameter, and hence large enough to penetrate the remaining atmosphere above it without disintegration.

It is therefore safe to conclude that at least one of the pellets ejected on October 16, 1957, escaped permanently from the earth into interplanetary space. For a preliminary report, see "The First Shots into Interplanetary Space," January, 1958, *Engineering and Science Monthly*. A detailed analysis of the data is to be published later.

F. ZWICKY
California Institute of Technology
Pasadena, Calif.

Sir:

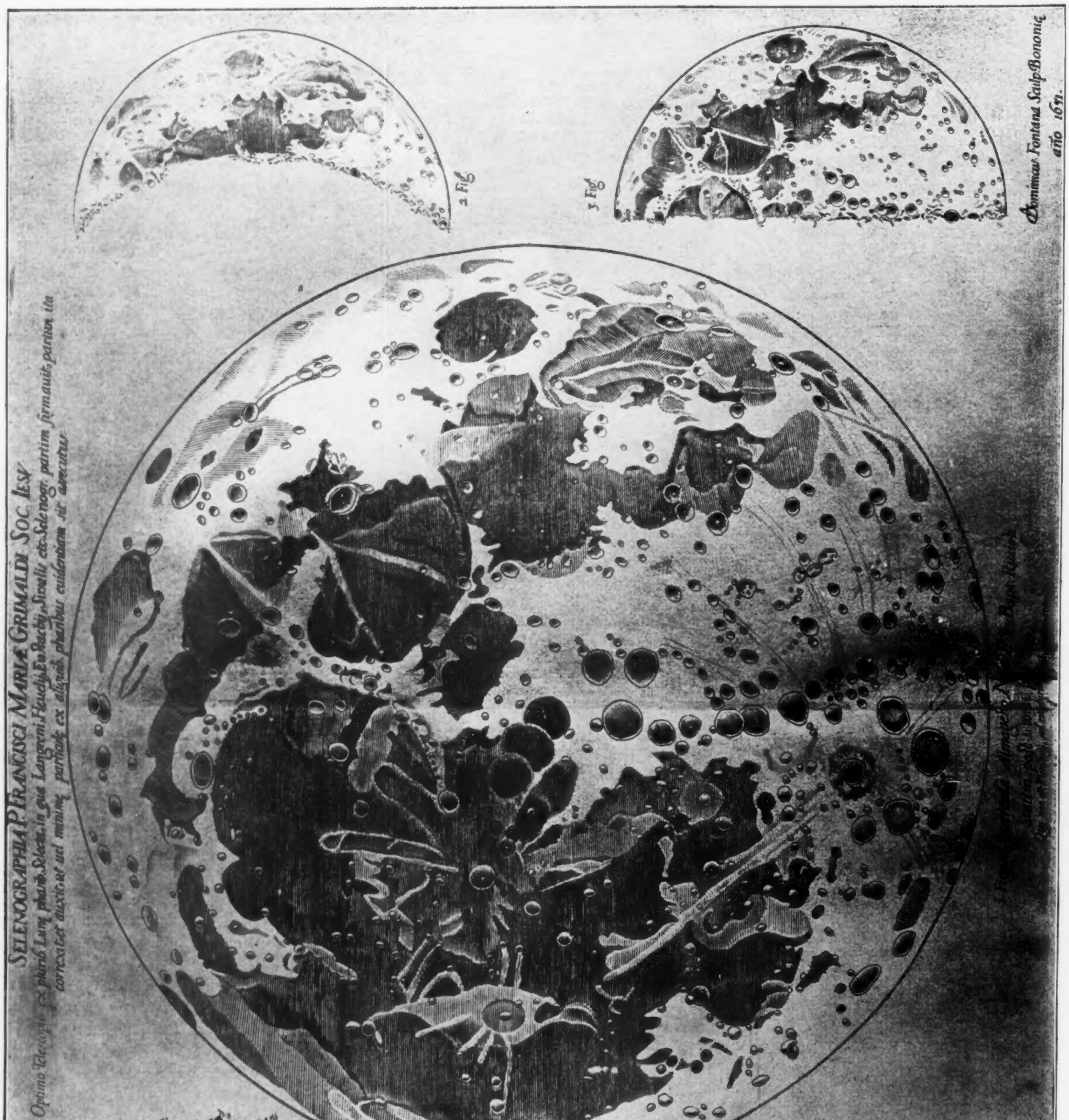
In connection with the News Note on page 626 of the October, 1958, issue, concerning the visual brightnesses of the Magellanic Clouds, the following information is of significance.

For the Large Cloud, the total magnitude has been independently determined photographically (G. de Vaucouleurs, *Astronomical Journal, 62,* 69, 1957) and photoelectrically (O. J. Eggen and G. de Vaucouleurs, *Publications* of the Astronomical Society of the Pacific, *68,* 421, 1956). For the magnitude in visual light, the results are in close agreement: + 0.30 ± 0.05 over a 200-square-degree area, and + 0.30 ± 0.04 over a 153-square-degree area, respectively.

The first paper gives the integrated magnitude of the Small Cloud as + 2.40 ± 0.05 over 25 square degrees, while H. Elsässer's photoelectric value, also for visual light, is + 2.72 over 13.5 square degrees (*Zeitschrift für Astrophysik, 45,* 24, 1958).

The magnitude value of −1.0 for the Large Cloud attributed to me in the News Note was published at Mount Stromlo Observatory in 1954 as a possible correction to much earlier data that have been superseded by the observations described above.

G. DE VAUCOULEURS
Harvard Observatory
Cambridge 38, Mass.



This moon map of 1651 appeared in G. B. Riccioli's "Almagestum Novum," the book that introduced the system of names still in use for lunar craters, seas, and mountains. The drawings were made by F. M. Grimaldi, who also discovered the diffraction of light. He has inserted in the seas bright patches conspicuous only near full moon, which are features neglected by modern cartographers. Grimaldi's map shows Linne as a crater and not as a bright spot, its present appearance in small telescopes. This may only mean that an error was made by the 17th-century engraver, instead of being evidence that this lunar formation actually underwent change, as some astronomers believe.

ASTRONOMICAL SCRAPBOOK

Names on the Moon

FOR a cloudy evening's reading, *Who's Who on the Moon* can be heartily recommended. Although out of print, you can sometimes locate it in libraries as Volume 34, Part 1, of the *Memoirs* of the British Astronomical Association. This slim volume identifies hundreds of the men after whom lunar craters have been named, giving short biographical sketches.

It is an absorbing experience, while browsing through its pages, to feel strange-sounding names on a moon map change into flesh and blood. In this book you can find who Fracastorius and Santbech were, and why Plutarch has a crater named after him.

About 200 of the larger surface formations bear names originally chosen by the Italian astronomer G. B. Riccioli in 1651, mainly from the ranks of famous astronomers and mathematicians. At the end of the 18th century, J. H. Schröter added some 60 more, while W. Beer and J. H. Mädler contributed 145 additional crater names in the 1830's.

As long as selenographers were few, this process led to little confusion. But during the middle of the 19th century, W. R. Birt in England and J. F. J. Schmidt in Greece were independently charting the moon and assigning new names. The nearly simultaneous publication of E. Neison's handbook *The Moon* (1876) and Schmidt's great lunar atlas (1878) unleashed many fresh discrepancies of nomenclature.

Thus there came to be two craters named Beer, two Argelanders, and two Birts. Worse still were tangles of the following sort: "Schmidt's 'Plutarch' seems to be identical, or nearly so, with Mädler's and Neison's 'Seneca'; while he calls their 'Plutarch' 'Timoleon,' a new name chosen by himself. Schmidt's 'Seneca' is a formation west of 'Hahn,' not named by Mädler or Neison."

Roman letters attached to crater names (for example, Archimedes A) had come into general use to indicate smaller craters in the vicinity of a named formation, and there were hundreds of cases where these designations were inconsistent among the authorities just mentioned.

This chaos was long both an exasperating inconvenience and a source of frequent error in lunar literature. In 1905 S. A. Saunder in England urged that an international committee undertake the reform of lunar nomenclature, and he gained the support of the Royal Astronomical Society and the Royal Society. On this stimulus, in 1907 the International Association of Academies formed a committee for the purpose, under the chairmanship first of M. Loewy of Paris Observatory and later H. H. Turner of Oxford.

The first fruit of the committee's work was the publication in 1913 of a book by Mary A. Blagg, *Collated List of Lunar Formations Named or Lettered in the Maps of Neison, Schmidt, and Mädler*. This list of nearly 4,800 lunar features gives for each the designations employed by these three authorities, information to assist in its identification, and in many cases critical notes.

After World War I, when the International Astronomical Union was formed, Commission 17 was assigned responsibility for lunar nomenclature. With Turner as president, its membership of Miss Blagg, G. Bigourdan, W. H. Pickering, and P. Puiseux reconstituted the prewar committee.

From the labors of Commission 17 came what is probably the most useful of all reference works for the serious student of the moon, *Named Lunar Formations*, by Miss Blagg and K. Müller. The first of its two volumes is a catalogue of about 6,000 lunar place names, each with its co-ordinates, brief description, and indication of the original authority for the name. The numeration of the *Collated List* has been retained, so that it is an easy matter to track down the earlier aliases of some particular crater. The second volume is a lunar atlas embodying the standardized nomenclature. Its 14 sections, on a scale of 37 inches to the lunar diameter, were drawn by W. H. Wesley and Miss Blagg from the best photographs available, the correctness of the plotting being established by the thousands of selenographic positions measured by Saunder and J. Franz.

The consistent and unambiguous system of lunar nomenclature embodied in this report was officially adopted by the IAU in 1932, and both parts of *Named Lunar Formations* were published by the Union in 1935. In his preface, the Astronomer Royal, F. W. Dyson, noted: "These names should be strictly adhered to by selenographers. Those who may wish to add new names should ascertain from the list whether the proposed names have already been given to other formations. Also no new name should be given to a formation already named in the list. Otherwise new confusions will arise similar to those which have with difficulty been cleared away."

With the completion of its work, Commission 17 was disbanded, and its jurisdiction over lunar nomenclature was transferred to Commission 16, on physical studies of planets and satellites, whose present chairman is G. P. Kuiper.

Logically, it might be supposed that this would have ended for many years the history of naming craters. However, in the past two decades about 100 changes and additions have been entered by the English amateur astronomer, H. P. Wilkins, on his large and detailed lunar atlases, and also published in *The Moon*, by Wilkins and P. A. Moore.

Because the status of these names has been widely misunderstood, it should be pointed out that they have not been accepted by Commission 16, and are therefore unofficial. They fall into two classes.

Some refer to craters in the limb regions of the moon, brought into view only by favorable libration, and hence previously undesignated, as *Named Lunar Formations* excluded objects lying entirely beyond the limb at mean libration. Thus these new names can serve a useful purpose.

In the other class are well-known craters to which the IAU had assigned letters, such as Archimedes A and Vitruvius B, for which Wilkins has used the names Gant and Fisher, respectively. Unlike the new limb designations, these do not fill a hitherto unsatisfied need, and conflict with the intention of the IAU as quoted above.

Some of the unofficial crater names happen to be so similar to other designations as to invite needless confusion. The name *Cooke*, advanced by Wilkins, is apt to be interchanged with the long-known *Cook*, especially as they are located in the same general area of the moon. Another instance is a new name due to the Spanish selenographer A. Paluzie-Borrell, which is printed in the Wilkins-Moore book both as *Rhodes* and *Rodés*, while the label *Rodes* has been assigned unofficially to another crater, Lalande A, by F. Chemla-Laméch.

Nevertheless, a fraction of the unauthorized recent names do honor to astronomers, both amateur and professional, who have made valuable contributions to selenography, and for whom a place on the moon would be fitting. It appears likely that lunar probes may soon make it possible to map the hitherto invisible part of the moon's surface. Therefore newly discovered craters there could be named from among the recent proposals offered for the near side of the moon, where the IAU nomenclature would continue unchanged.

JOSEPH ASHBROOK

ASTRONOMICAL EXHIBITION

A collection of historical astronomical books, charts, and instruments is now on display at the Florida State Museum, Gainesville, Florida. The exhibits cover nearly 4,000 years, from a Babylonian clay tablet of about 1750 B.C. bearing a list of constellation names in cuneiform, to a painting of colliding galaxies by a contemporary artist, Antonio Petruccelli, of Mt. Tabor, New Jersey.

The telescopes on display include a 17th-century Italian instrument and small refractors by Dollond and Fraunhofer. Accompanying them are such historic books as the first edition of Galileo's *Dialogues* and Tycho Brahe's own description of his observatory at Uraniborg.

Amateur Astronomers

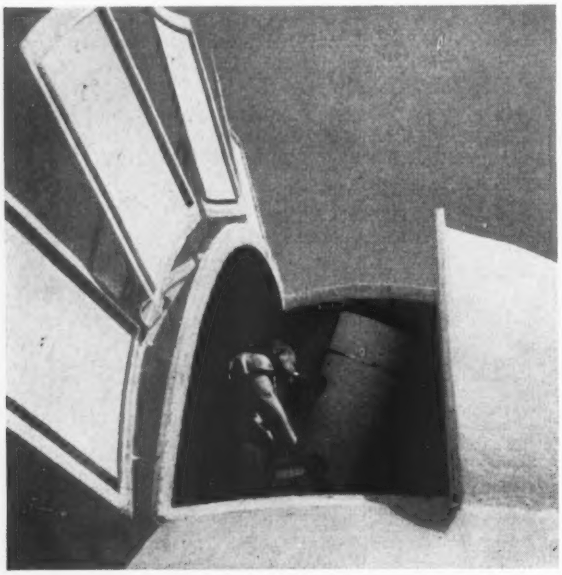
A Complete Observatory of Relatively Low Cost

LAST SPRING I constructed a 12½-inch reflector, using the elaborate shop facilities of Le Tourneau Technical Institute in Texas, and that summer at my home in Ft. Myers, Florida, I erected for it a concrete observatory with revolving dome, shown in the accompanying pictures.

Because of the poor subsoil, the building rests on a hexagon-shaped reinforced concrete slab 10 inches thick, and there are several reinforcements under the perimeter of the slab to add extra support to the wall. The telescope mounting is placed in a hole two feet square in the center of the slab.

Materials for the building itself were not a problem, as my father is in the concrete-block business. To make a better circular structure, I used half blocks, which are eight-inch cubes. The wall is five feet eight inches high. The diameter of the dome is 12 feet, giving a one-foot clearance for the end of the telescope tube, which is eight feet long and balanced five feet from its upper end.

My budget for the dome was $500, but fiberglass or aluminum would have cost over $800, so a friend suggested using his newly developed product – "rubber slate" – a mixture of pulverized paper, tar, and clay. This material is waterproof and has good insulating properties, but a one-inch layer weighs about six pounds per square foot, necessitating the very heavy framework seen in the photograph below.



The observing slit of Robert Goetz' observatory at Ft. Myers, Florida, is three feet wide, amounting to a quarter of the dome's diameter. The four hinged doors are of galvanized metal, held to the "rubber-slate" dome by bolts with oversized washers on the inside. The doors, which were rolled to fit the dome contour, overlap snugly when they are closed.

To support the unusual weight, six cast-iron cable sheaves six inches in diameter run on a track of ⅜-inch flat bar, which was rolled to the dome curvature in three 12-foot lengths that were welded together.

The dome frame was made of ½-inch steel reinforcing bar, each piece cut to the right length and rolled to the dome contour. An unexpected workout in mental gymnastics was required for the complex calculations of the positions and dimensions of the framework components. Thin metal lath to hold the rubber slate had to be wired to the frame by hand, and then began the rather messy job of applying 2,000 pounds of the mixture, three coats on the outside and one on the inside.

The final operation was to plaster and paint the building, its outside walls being light green, the inside light blue. A special white paint was used to treat the dome, since the rubber slate is quite absorbent and never really solidifies.

I have been interested in telescope making since the age of 12. Wanting to share my enthusiasm in astronomy, I was active in forming the East Texas Astronomical Society in Kilgore.

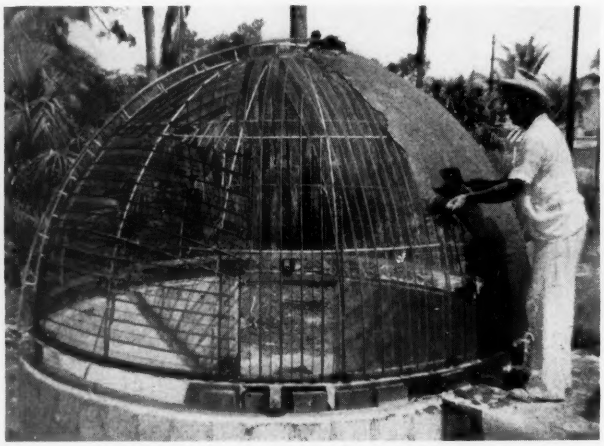
ROBERT GOETZ
Le Tourneau Technical Institute
Box 116, Longview, Tex.

NATIONAL MEETING NOTES

The deadline for requesting program time at the National Amateur Astronomers Convention this August 28-31 at Denver, Colorado, has been extended to April 1st. The committee that will consider applications was listed on page 142 of the January issue.

Since all papers selected will be printed in the *Proceedings*, they should be submitted in duplicate, typewritten double-spaced on one side of each sheet. Sketches, drawings, and photographs should be of sufficient contrast to permit clear reproduction.

Ample room is being set aside for the



At the left, a friend of Mr. Goetz helps lay the last section of the wall. The topmost course is of U-shaped block to carry the track and base for the dome support. At the right, the "rubber slate" is applied to the dome framework, the latter being rotated to bring new working areas to the position of the scaffold. Eight persons were needed to lift the 700-pound framework onto the track atop the circular wall.

exhibit of exceptional amateur equipment. Those interested should submit their space and electrical requirements, as well as a complete description and photograph of the equipment, to the exhibit chairman, Henry D. Fiske, 2273 S. Fillmore St., Denver 10, Colo.

SOCIETY LISTING

The April issue is tentatively scheduled to carry Here and There with Amateurs, the listing of all amateur groups that have registered with SKY AND TELESCOPE. Any changes in the previous listing, beginning on page 569 of the September, 1958, issue, should be sent to this magazine by February 15th. Clubs that were not included there and whose membership is open to the public should write for a registration blank.

LATIN-AMERICAN AMATEURS ORGANIZE LEAGUE

The first international amateur astronomers convention in Latin America was held October 14-20, 1958, in Santiago, Chile, when some 60 delegates formed the Liga Latinoamericana de Astronomia (Latin-American Astronomical League). The meeting was organized by the Chile Astronomical Society and sponsored by the Catholic University of Chile. In attendance were amateurs from Argentina, Chile, Colombia, Ecuador, Nicaragua, and Peru.

The league will promote interest in astronomy among Latin-American amateurs. It will co-operate with professional astronomers and sponsor certain observing programs, such as detailed observations of variable stars and sunspots. A bulletin is also planned.

The headquarters for the league will rotate among member societies; at present it is in Lima, Peru. Conventions are to be held every two years; the next is scheduled for Lima in January, 1961.

Officers of the new organization are: Victor Estremadoyro R., president; Augusto Cornejo P., general secretary; and Gustavo Estremadoyro R., secretary of publications.

Interested Latin-American societies are requested to write the president at Enrique Palacios 187, Chorrillos (Lima), Peru, for further information.

UNION CITY, NEW JERSEY

The Hudson County Astronomical League was organized last August and now has 20 members. The secretary is Sal Giardina, 631 13th St., Union City, N. J.

LAUREL, MISSISSIPPI

There are 40 members, seven of them juniors, in the Laurel Sky Club. Interested amateurs should communicate with Herbert H. Dyke, 11 Country Club Dr., Laurel, Miss.

THIS MONTH'S MEETINGS

Baltimore, Md.: Baltimore Astronomical Society, 8 p.m., Enoch Pratt Library. February 16, Dr. Robert Jastrow, National Aeronautics and Space Administration, "Recent Developments in Upper-Atmospheric Physics."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health Museum Planetarium. February 23, Bill Daniel, "New Information About Unidentified Flying Objects."

Lemont, Ill.: Argonne Astronomy Club, 8 p.m., chemistry building, Argonne National Laboratory. February 18, Dr. Frank S. Tomkins, Argonne National Laboratory, "Stellar Spectroscopy."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. February 11, Theodore E. Houck, Washburn Observatory, "Taking Pictures of the Sky."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. February 4, Dr. Edward L. Fireman, Smithsonian Astrophysical Observatory, "Sampling the Solar System for Isotopes."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. February 20, Dr. Martin Schwarzschild, Princeton University Observatory, "Project Stratoscope."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. February 13, A. B. Tonik, Remington Rand, "Astronomy Problems on the Digital Computer."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. February 7, Dr. E. J. Opik, Armagh Observatory, "Surface Conditions on the Nearest Planets."

CHINA LAKE, CALIFORNIA

There are 34 members in the China Lake Astronomical Society. The corresponding secretary is James R. Deal, 102-B Lauritsen, China Lake, Calif.

SAN GABRIEL, CALIFORNIA

The San Gabriel Valley Astronomical Society was recently formed, with a charter membership of about a hundred. There are monthly field trips to suitable observing sites, and the society sponsors bimonthly lectures by professional and amateur scientists. A workshop on practical astronomy has also been set up. Further information may be obtained from Frances Howden, Box 530, Monrovia, Calif.

WENATCHEE, WASHINGTON

The North Central Washington Astronomical Society has recently been formed, with 16 amateurs. It has joined the Northwest Region of the Astronomical League. The secretary is Hugh C. Kirkpatrick, Rte. 4, Box 4100, Wenatchee, Wash.

NEW PLANETARIUM IN TENNESSEE

The latest community project of the Barnard Astronomical Society was realized last November, when a new planetarium at the Clarence T. Jones Observatory in Chattanooga, Tennessee, began its program of Friday night demonstrations. It is open free to the public, as is the observatory.

Donated to the University of Chattanooga, the planetarium is housed in a 25-foot addition to the observatory building. The chamber dome is 24 feet in diameter. A gift of $12,500 was given anonymously for construction of the new wing.

In 1951, the planetarium project was initiated by Mr. Jones, who was the builder of the 20½-inch fork-mounted Cassegrainian telescope in the observatory. Within a year, however, he passed away, and the society continued the project. The projector is a 12-sided device, each face of which projects part of the heavens. The control console was designed by Clarence J. Gearhart, an instrument repair man.

Society members donated their services in painting the entire new wing, including a skyline of the city around the dome. They also repainted the observatory building, which was built as a project of the society more than 20 years ago.

BRENTWOOD, TENNESSEE

In March, 1956, the Brentwood Astronomy Club was organized, and now has nine members between the ages of 15 and 18, as well as an adult leader. The society has an equatorially mounted 8-inch reflector, for which slow-motion controls and a clock drive are being constructed. The wooden tube is large enough for a 10-inch mirror.

A solar observing program and a mirror-making group are planned. For further details, contact Robert Vaughn, Valley View Rd., Brentwood, Tenn.

GEORGIA AMATEUR DIES

The founder of the Atlanta Astronomy Club, Fredrick Preston Rose, died on November 21, 1958. He had been active in amateur astronomy for many years, and owned several telescopes, the largest a 10-inch Springfield-mounted reflector. He was a printer by profession.

KANKAKEE, ILLINOIS

Eight juniors have formed the Kankakee Junior Astronomers. Further information may be had from Dave Soucie, 235 S. Gordon, Kankakee, Ill.

BETHPAGE, NEW YORK

Twenty-four amateurs comprise the Grumman Astronomical Society. More information is obtainable from Richard T. Inman, 10 Radcliff Lane, S. Farmingdale, N. Y.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Observing the Moon — Gassendi

AN IMPOSING lunar walled plain is Gassendi, conspicuous at the northern edge of Mare Humorum and well placed for observation a few days before full moon. Because of its easy visibility and the great amount of detail on its floor, Gassendi has been one of the most frequently studied formations on the moon.

About 69 miles in diameter, according to J. Young's measurements, it is bounded by irregular walls which show traces of a polygonal pattern. While the crater is actually nearly circular, foreshortening causes it to appear as an ellipse, whose form varies perceptibly as the moon's librations swing it nearer to or farther from the center of the disk.

The walls have a considerable range in height, with their greatest elevation on the east, where two prominent peaks reach about 8,000 feet above the floor. Between these peaks is a conspicuous landslide, evidence of a partial collapse of the wall at some time in the past. The western ramparts contain some pinnacles that are not much lower, and are probably most striking just before sunset occurs on this portion of the moon, at age 26 days.

The northern portion of the wall is very irregular, with many terraces on its inner slopes. It is broken by the 22-mile crater Gassendi A, for which H. P. Wilkins has proposed the name Clarkson. Gassendi A has some detail on its floor, and several faint and usually difficult dusky bands on its inner east slopes. East of this crater, the rim of Gassendi has two narrow notches, through which two easily seen clefts pass northward from the interior to as far as Letronne.

On the south, adjoining Mare Humorum, the walls are much lower and narrower, being reduced to mere ridges in places, and at one point completely broken. Because the floor of Gassendi inside the south wall looks much like the neighboring sea floor, it seems possible that at some time in the past the mare material invaded the interior of the crater through this gap in the wall.

The interior of Gassendi is marked by a large mountain complex, just west of the center. Its highest peak, Gassendi β, reaches 3,600 feet, according to J. F. J. Schmidt. One mountain to the east of the principal group has a tiny summit craterlet, suggestive of a terrestrial volcano. The craterlet is difficult to see except in larger telescopes, and is probably most easily observed under a high sun, when it appears as a minute white spot on the mountaintop.

Gassendi is famous for the intricate system of clefts on its floor. These rills or cracks have been carefully studied by selenographers for many years, and certain observers have set their number as high as 40. Some clefts can be seen in fairly small telescopes, but most are very delicate features requiring large apertures. Small changes in illumination and libration greatly influence their visibility, and hence the entire system is never seen at one viewing. No two observers seem to draw the same cleft pattern, for which no truly accurate chart exists, even though the interior of Gassendi has been so often observed. These finer details are not shown on the best photographs I have seen.

The most prominent portion of the cleft system lies south and southwest of the central mountains. Easiest of all to see are the two diverging clefts on either side of the largest interior craterlet. Under favorable conditions, 3- or 4-inch telescopes should show them. West of these clefts is a conspicuous ridge which continues at each end as a series of delicate branching clefts. The long rifts near the center of the crater are difficult objects, rarely seen in their entirety. Because the charts by various observers differ widely as to the number and positions of the clefts in this vicinity, much further study is needed.

Alika K. Herring made this drawing of the lunar crater Gassendi on August 7, 1957, at 5:45 UT, with powers of 228 and 342 on his 12½-inch reflector. Morning sunlight has spread over most of the crater's floor, the sun's altitude being about eight degrees for this part of the moon. The shadow-filled crater at the bottom is Gassendi A, with walls about 10,000 feet high. South is at the top, west to the left. Although shown nearly circular in the drawing, Gassendi appears elliptical to us because of foreshortening toward the limb of the moon; the crater's shortest diameter extends from lower left to upper right, as oriented here.

The largest interior craterlet, Gassendi N, is intersected by several very delicate clefts. Several years ago, F. H. Thornton in England noted one that passes through the craterlet from northwest to southeast, connecting with the wider clefts on each side. Recently I saw another short cleft running northeast from Gassendi N, which therefore seems to be the hub of a radial system of small fissures. These are difficult objects for a good 12-inch telescope.

Gassendi resembles many other walled plains in having a well-developed line of clefts and ridges that are more-or-less concentric with the outer walls. Beginning near the southwest wall, we find a conspicuous ridge which tapers off eastward to two diverging clefts, and after a short distance these revert to ridges. The southern cleft of this pair is short, and ends in some low hills; the northern one is longer, and continues as irregular ridges which may be traced as far as the confused highlands between Gassendi A and the central mountains. At this point a cleft appears, extending southward with one minor break until it meets the northern end of the ridge, to complete the circuit.

Gassendi is sometimes described as having an inner ring, the fragmentary remains of a crater older than the present outer walls. For the reasons given on page 464 of July, 1958, in connection with the analogous case of Posidonius, I believe this interpretation is incorrect. In this instance, too, it appears that the clefts formed first, as the crater floor subsided, and the ridges were then produced by volcanic activity along these lines of weakness.

Many other craters show inner rings of this character, and systematic observations of them may yield important clues concerning the evolution of lunar formations.

ALIKA K. HERRING
3273 Liberty Blvd.
South Gate, Calif.

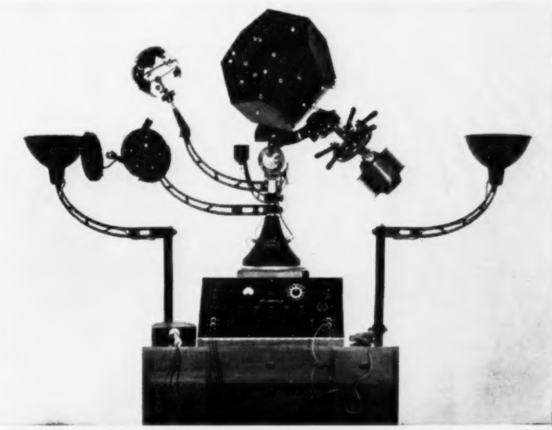
SUNSPOT NUMBERS

The following American sunspot numbers for November, 1958, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

November 1, 170; **2**, 196; **3**, 192; **4**, 136; **5**, 125; **6**, 87; **7**, 108; **8**, 99; **9**, 75; **10**, 86; **11**, 69; **12**, 75; **13**, 59; **14**, 54; **15**, 68; **16**, 66; **17**, 34; **18**, 51; **19**, 73; **20**, 85; **21**, 105; **22**, 118; **23**, 135; **24**, 179; **25**, 197; **26**, 242; **27**, 200; **28**, 279; **29**, 222; **30**, 215. Mean for November, 126.7.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

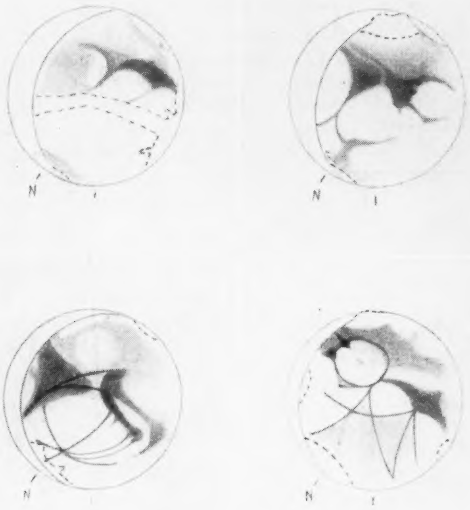
December 1, 241; **2**, 234; **3**, 228; **4**, 221; **5**, 238; **6**, 218; **7**, 242; **8**, 262; **9**, 247; **10**, 232; **11**, 224; **12**, 211; **13**, 198; **14**, 185; **15**, 150; **16**, 142; **17**, 124; **18**, 109; **19**, 91; **20**, 77; **21**, 92; **22**, 114; **23**, 150; **24**, 185; **25**, 222; **26**, 239; **27**, 206; **28**, 170; **29**, 162; **30**, 172; **31**, 156. Mean for December, 185.2.



Some Observations of Mars from Iran

FOUR DRAWINGS of Mars reproduced here were made in September and early October, over a month before opposition on November 16, 1958, and continue the series on page 95 of the December issue. Those drawings show the planet as seen in different wave-length ranges at the same observing session; these four combine the details seen at each session through a variety of filters.

All of the drawings were made at Shiraz Observatory, Iran, with a 7-inch Cassegrainian reflector. The first was made by my wife and me on September 4-5, from 23:05 to 0:25 Universal time, using 318 power and Wratten filters 23, 57, and 38.



Four views of Mars as it was nearing opposition in 1958, drawn by Charles F. Capen, Jr., with a 7-inch reflector at Shiraz, Iran. These sketches were made September 4-5, 8, 23, and October 8, when the longitude of the Martian central meridian was 114°, 50°, 317°, and 118°, respectively. On these dates, the diameter of the disk of Mars was 12.9, 13.2, 14.8, and 16.9 seconds of arc, respectively. Tick marks labeled "N" indicate north in the drawings.

The south polar cap had a notable rift and a small dark periphery, and the whole region was covered with a hood of haze. A veil also covered the Aurorae Sinus and about half of the Solis Lacus region. An equatorial cloud band was clearly seen with all filters, but was most prominent in blue light (filter 38). A ragged white area was visible on the sunrise limb. All of the southern maria were gray-green.

On September 8th, from 20:30 to 23:40 UT, the planet was observed through no fewer than nine filters in turn (Wratten 15, 23, 57, 64, 38, 36, 39, 82, and 47). Powers of 106 to 424 were employed.

Both polar caps were seen through light Martian clouds. These polar hoods were best pierced with the yellow-green 57 filter, while in blue light they stood out strongly. Many definite white areas were noted. The terminator projection and the cloud in the Noachis-Mare Australe region were equally well seen in blue-green and blue light. The southern-hemisphere maria were gray-green to blue-green.

The third drawing, on September 23rd at 0:45 UT, was made with 450x and filters 15, 25, 64, 38, and a polarizer. The south cap was extremely small, while the north cap was bright and strangely irregular in shape.

A white, bright area covering the

Ausonia region appeared to extend into the terminator (upper left). Filters were used to check for possible terminator cloud formations; when the polarizer was used to cut irradiation the apparent projection disappeared. Therefore, this phenomenon may have been Martian ground frost.

In the final view, at 450x on October 8th from 20:30 to 21:42 UT, filters 21, 57, 38, 64, 47, and a polarizer were employed. The south cap was not seen at all, while the north one was detectable through a hood of haze. By this date the general cloudiness of the earlier views had disappeared. A terminator cloud projection was best seen in blue-green light (64), and was still noted through the polarizer. Two frost areas were recorded. All of the southern maria were now a dark green color. No Martian blue clearing could be detected.

CHARLES F. CAPEN, JR.
Satellite Tracking Station
Shiraz, Iran

DEEP-SKY WONDERS

FEBRUARY is a time of interesting change in the sky. Winter's gorgeous galactic clusters still swarm like golden bees in the west, while above the eastern horizon come the advance guards of spring's great galaxies. There is much to observe this month – easy objects for the newcomer, more difficult ones for the man with a large telescope who "has seen everything."

Among the easiest is Praesepe, the Beehive cluster, boxed neatly between four stars in Cancer, at right ascension $8^h 37^m.5$, declination $+19° 52'$ (1950 co-ordinates). Designated M44 (NGC 2632), it is one of the nearest galactic clusters, and can be studied in detail. Binoculars suffice for marvelous views, and even young amateurs in grade school often make elaborate charts of its many stars.

A 6th-magnitude cluster well worth looking for is M67 (NGC 2682), at $8^h 48^m.3$, $+12° 00'$, even though it is given but scant mention in handbooks. It lies between Praesepe and the blunt head of Hydra to the south; on very clear nights it can be added to an amateur's list of naked-eye sightings, and is a rewarding object in a small telescope.

In much the same fashion M35 (NGC 2168) in Gemini is an easy naked-eye object, of 5th magnitude, at $6^h 05^m.7$, $+24° 20'$. A telescope will show the faint cluster NGC 2158, an irregular and wispy neighbor of M35, overlapping the latter's southwestern edge. Norton's *Star Atlas* shows nothing else here, but the Skalnate Pleso *Atlas of the Heavens* adds IC 2157, a cluster at $6^h 01^m.8$, $+24° 02'$, which this writer has never recorded, although it ought to be within reach of his 10-inch telescope. Another faint 12th-magnitude cluster in Gemini is NGC 2355, at $7^h 14^m.2$, $+13° 52'$, which a 10-inch shows perfectly well.

Over in Leo is a fairly difficult spiral, NGC 2903, for which a beginner will really have to search, though an old-timer should have little difficulty. Located at $9^h 29^m.3$, $+21° 44'$, it is of the 10th magnitude and was recorded as a twin by William Herschel because he could see two centers of condensation. Photographs show that this object – NGC 2903 and 2905 – is really one confused and churned-up spiral, 11′ by 5′ in extent and of type Sc. The amateur viewing it in his telescope will probably agree with Herschel's impression.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

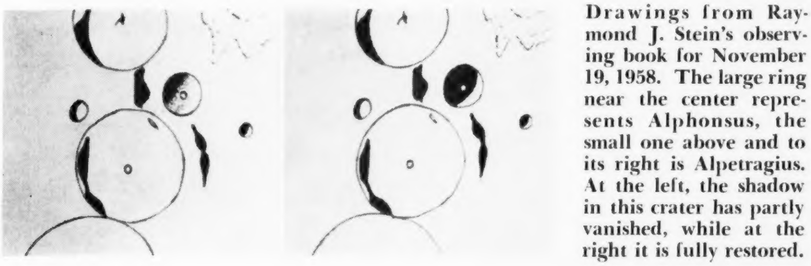
AN UNUSUAL EVENT IN ALPETRAGIUS

On the evening of November 19, 1958, I went up on the roof of the Newark Museum with a 4-inch reflector to select the site for an observing platform. So good was the seeing that I spent some time examining the moon, whose image was quite sharp at 195x. The moon was just past first quarter, the terminator being about two diameters of Alphonsus from the east wall of that crater.

At 22:00 Universal time, I suddenly noted that a portion of the shadow covering the floor of the nearby crater Alpetragius had faded. A few minutes before, this shadow had covered about two-thirds of the interior of the crater, with the central peak a bright spot on a black background. Now, however, about half the shadow had faded, and was replaced by a much lighter shade. I did not see any glow or haze in the crater. At 22:05 UT the shadow gradually darkened, reaching its former state in about 20 seconds.

During the past six years I have been observing the moon regularly, generally with larger apertures than four inches, but I never saw anything like this before. The fading of the shadow could not have been caused in our atmosphere, since formations surrounding Alpetragius were unaffected. It seems certain that the phenomenon was not caused within the telescope, as I let Alpetragius drift three times across the entire field of view during the interval from 22:00 to 22:05, without noting any change in appearance at any point. The explanation of the event is uncertain, and may require a comparison with analogous instances of change reported by other observers of our satellite.

RAYMOND J. STEIN
Newark Museum Planetarium
Newark 1, N. J.



Drawings from Raymond J. Stein's observing book for November 19, 1958. The large ring near the center represents Alphonsus, the small one above and to its right is Alpetragius. At the left, the shadow in this crater has partly vanished, while at the right it is fully restored.

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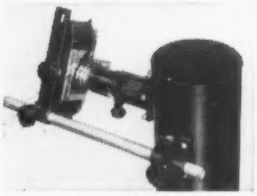

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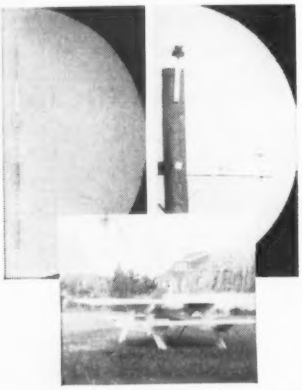

These untouched photos show bottom view taken with regular camera. Also ones taken with our #127-size-roll-film telescope camera on our 4¼" reflecting telescope. The telephone pole seen in right-hand picture is 300 yards away. TV antenna at left is about 4 miles away.

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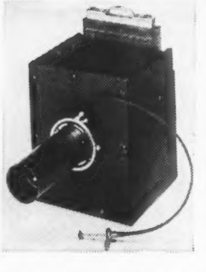

Here is a special camera for taking excellent closeup shots through your telescope — pictures of the moon, stars . . . terrestrial telephoto pictures. Sturdily built, easily operated, this useful camera employs sheet film. One filmholder, size 2¼" x 3¼", is included. Camera lens is 4-element — not only magnifies the image but extends it from normal eyepiece image plane to film plane. Yellow filter included. Camera box size is 3" x 4" x 5". Tube that fits into eyepiece holder is 5" long with 1¼" O.D. for standard telescopes. Cable release and 3¼" x 4¼" piece of ground glass for focusing also included. Precision German-made shutter has settings for Time, Bulb, 1, ½, 1/5, 1/10, 1/25, 1/100, and 1/200 second. Also has delayed-action shutter release.

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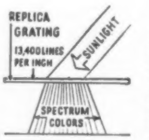

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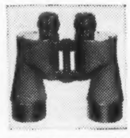

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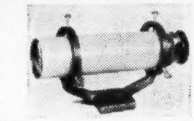

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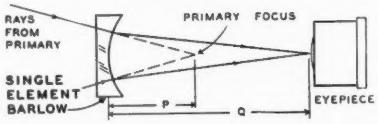
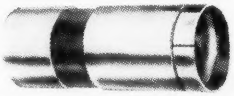


WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

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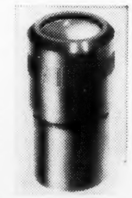

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BOOKS AND THE SKY

HANDBUCH DER PHYSIK, VOL. 50 ASTROPHYSICS I: STELLAR SURFACES – BINARIES

S. Flügge, editor. Springer-Verlag, Berlin, 1958. 458 pages. DM 98.

THE APPEARANCE of this book, the first of five volumes on astrophysics, will be welcomed by astronomers and students the world over. A new *Handbuch* in this mushrooming science has been badly needed for many years, and these volumes will undoubtedly make their presence felt to an even greater extent than did their predecessors of the 1930's. They should be required reading for all serious students of astronomy, and will be useful in planning both research programs and graduate lectures.

Volume 50 has 10 chapters – five in English, three in French, and two in German. Almost 60 per cent of the text is in French, however, from the two longest contributions: C. Fehrenbach on the spectral classification of normal stars (92 pages), and D. Barbier on the general theory of stellar atmospheres (125 pages). Either of these two chapters, for those who would read and absorb them, is worth the price of the book.

The language barrier will undoubtedly keep many American scientists from reading these and the other non-English contributions in the *Handbuch*. The fundamental importance of this material surely justifies a readily available English translation, and no doubt "unofficial" graduate-student translations will soon be made. French is a comparatively easy language to learn to read, but the technical vocabulary is still a formidable obstacle for the beginner.

A fairly large sample of the three French chapters indicates that half of the text is based on only 40 words, 78 per cent on a total of 250 words, and 86 per cent is derived from a total of 500 different words. Almost half of these will *not* be found in a popular basic French vocabulary of 1,000 words. The point I wish to make is that a few hours a day (for a few days) of straight memory work with proper vocabulary cards should enable the beginning student to read with some fluency the sort of French found in this and other volumes of the series.

Besides numerous detailed references at the end of each chapter, its author has given a very useful and carefully selected general bibliography. An analysis of the 600 references given by the French and German authors shows that 43 per cent of these papers are by American astronomers, two per cent are by Russians, and 28 per cent of them are not in English. In the 280 references given by the American authors, 72 per cent are to papers by American astronomers, three per cent are by Russians, and only 13 per cent are not in English.

It is difficult to believe that Russian astronomy has made as small a contribution as indicated by these percentages; rather, the Cyrillic barrier must be a very real one. The relative figures tend to confirm the well-known predilection of American scientists for ignoring foreign-language literature. This unhappy situation will probably get worse before it gets better, inasmuch as the percentage of high school students studying foreign languages in this country has shown a fantastic decrease in the past 40 years.

The eight shorter chapters in this volume are: Stars with Peculiar Spectra (P. C. Keenan), Molecular Bands in Stellar Spectra (P. Swings, in French), The Spectra of Planetary Nebulae (K. Wurm, in German), The Spectra of the White Dwarfs (J. Greenstein), Visual Binaries (P. van de Kamp), The Eclipsing Binaries (S. Gaposchkin), Spectroscopic Binaries (O. Struve and S. S. Huang), and Theory of the Planetary Nebulae (K. Wurm, in German). A chapter on the Hertzsprung-Russell diagram by H. C. Arp, originally scheduled here, will appear in Volume 51.

I found Keenan's and Greenstein's chapters, and the one on spectroscopic binaries, to be especially instructive and interesting, although any of these eight shorter chapters can be read with profit

in from one to three hours. The three chapters on binaries reflect the shift of attention from purely formal orbit solutions to more general astrophysical questions. For example, there are at least two noteworthy contributions to spectroscopic binary theory published since the last *Handbuch* that are not found in the present volume, and there are even more such developments in eclipsing binary theory.

The chapter that presents the most original work is by Greenstein. It will undoubtedly remain *the* fundamental paper in the difficult problem of the spectroscopic observation and analysis of the very numerous and faint white dwarfs. This is exactly the type of problem that requires such magnificent equipment as can only be found at Palomar Observatory, and it is a sad commentary on the state of our observational facilities that the numerous known white dwarfs south of −45° are out of reach in this respect. Greenstein's last sentence is worth quoting: "At the other end of history, one can predict that the cooling, reddening and nearly 'black' white dwarf represents the ultimate dying stage of matter in our Galaxy."

The history of spectral classification is traced in Fehrenbach's chapter from the time of Father Secchi through Miss Maury, Miss Cannon, and the *Henry Draper Catalogue*, up to B. Strömgren's recently developed narrow-band photoelectric methods. Two-dimensional classifications are discussed in considerable detail, and the fundamental Johnson-Morgan photoelectric-spectroscopic techniques and results are given. Useful comparisons are made between various classification systems. The important contributions of the Swedish and French astronomers are well presented. Very low-dispersion "discovery" programs, such as those at Warner and Swasey Observatory for the *M* stars and at Yerkes Observatory for the early-type stars, are discussed, as are Nancy Roman's strong- and weak-line stars.

The field of spectral classification has always been a richly rewarding one and holds promise of an even brighter future. Since this chapter was written, Strömgren and R. Crawford have shown how the relative ages of stars in open clusters — and even of isolated stars — can be derived from the analysis of photoelectric observations. Strömgren has extended such analyses to the determination of metal-hydrogen ratios — basic to our understanding of stellar evolution.

The time seems ripe to apply these well-tested, quick, and highly precise techniques on a large scale. We need a modern two- or three-dimensional *Henry Draper Catalogue* that would give spectral classifications and stellar luminosities to a new order of accuracy; such a catalogue would profoundly influence and make more meaningful the work of the great reflectors. Unfortunately, there seems to be a strong tendency to regard large-scale observational programs of this scope as outmoded, with the further self-defeating thought that anything that can be done most effectively with a 20- or 30-inch telescope is scarcely worth the doing.

Barbier gives the best review of the theory of stellar atmospheres now available. Expertly written, it covers all the fundamental aspects without bogging down in details. Students will find it an excellent introduction to the subject, and professional astronomers will refer to it repeatedly. It is exemplary of what a *Handbuch* article should be. Here are basic discussions of stellar radiation, excitation and ionization, radiative transfer, model atmospheres, the curve of growth, line profiles, problems of extended atmospheres, and many applications and results.

The book is beautifully printed and illustrated, but there are a few too many typographical errors. In the first two chapters, for example, are such slips as: R. H. Curtis, Srömgren, Y. Gyldenkerne, se, spectragrams, Megellanic, and corbon. With a few exceptions, the scientific quality and critical discussions found in this volume impressed me as being better than those in the older *Handbuch der Astrophysik*.

JOHN B. IRWIN
Goethe Link Observatory
Indiana University

1001 QUESTIONS ANSWERED ABOUT ASTRONOMY

James S. Pickering. Dodd, Mead and Co., New York, 1958. 420 pages. $6.00.

THIS BOOK is one of the "1001 Questions Answered" series by the same publisher. Mr. Pickering has had long experience in replying to queries of the public interested in astronomy, and here gives ample evidence of his ability to select the question and provide the answer. He does this in 15 general areas, starting with the sun and ranging through a rather well-selected set of subdivisions. One of these covers a usually neglected field — biographical sketches of scientists from Thales to Einstein.

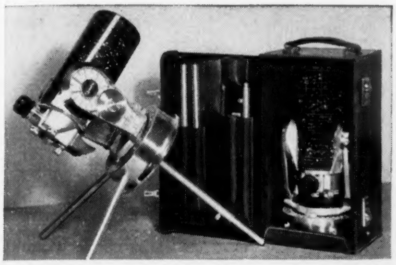
The manner of presentation is obvious from the book's title. Each question is in bold-face type, followed by the answer, which may consist of a line or two or several pages. Drawings of fair quality appear as needed in some places, but in the mind of this reviewer not nearly often enough. Sometimes the explanation of a minor point becomes tedious for lack of a simple drawing that could have cleared things up immediately.

Mr. Pickering expresses himself in an engaging and lucid manner, concise and easy to read. His answers are never stiff, and often have an informal character that reflects his experience and contact with the intelligent layman. He does not lose the reader in a mass of technical data or vocabulary. While this occasionally results in a slight impairment of rigor, it contributes much to the charm of the publication.

In reviewing a book of this series, one is led to appraise the plan of presentation and its effectiveness. Why are there a thousand questions about an area of knowledge? Actually, in this book there are 1,049, but some of the questions seem to have been dragged in by their heels. There are even duplications, such as questions 371, "What is an annular eclipse?" and 393, "What is meant by an annular eclipse?"

Even more problematical is the organization of the contents. The reader is frustrated by the lack of continuity. Although the general subdivisions men-

QUESTAR NEWS • *February, 1959*



For the benefit of newcomers, this is an advertisement for the Questar Telescope. In case you have not heard of it, it is pictured above and costs $995. This is nearly $100 a pound for the whole outfit in fine leather case, which is designed for you to take with you wherever you go. It takes a lot of doing to make Questars so short and light, but it certainly pays in comfort and convenience. Heavy automobiles are all right because you don't have to lift them — they carry you. So when you tire of lifting and carrying your heavy telescope, as many do, remember our beautiful little product was designed and built to relieve you of this burden. Ask for literature if you would care to hear more about Questar, which is sold only from the factory at wholesale price. (End of commercial — now we can ramble.)

We are tired of commercials, so we put ours at the top to get past it fast. We get awfully tired of sales talks. Blah-blah on the radio and blah-blah on TV. Buy, buy, buy, all day, all night. Go for a ride, the signs hide the view and continue hitting us over the head to buy. The net result is that you and I have been shouted at so much that we take a dim and skeptical view of what advertisers say. Anyone can be fooled, once, and most of us have been fooled by experts somewhere along the line. So we just discount everything the persuaders try to tell us, and justly so. Though they speak with the tongues of angels the best they'd better expect to get out of us is, "Say Joe, do you suppose that gadget is really any good?"

Does Anybody Read Us?

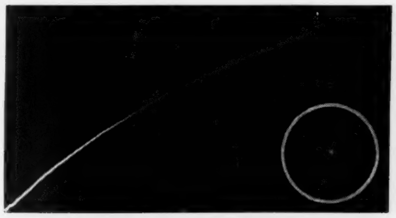
Out of the goodness of his heart — bless him! — Questar owner Fred Leisch, an executive vice-president by trade, dropped us a note recently in which he expressed concern at some Questar full-page ads that he felt might be all but pointless to readers unfamiliar with our product. He also thought we failed to emphasize some selling prose, and were falsely assuming that people read our ads from month to month. Mr. Leisch is probably right and we are doubtless breaking many rules of good advertising.

You can help us on this point — do you read us or not? We'd surely like to know and would welcome your comments, so drop us a line, will you? If people do read our page here, and we can hold their interest, they may eventually decide they need our product as they hear more about it. We suspect that no correctness of technique or cleverness on our part can persuade them to purchase. So we feel it doesn't matter, in the long run, if we "throw away" our best lines, as people of the theater would say.

Long-Distance Pictures of Moon Rocket Pioneer III

Did you know that rockets launched at night are visible for hundreds of miles? That people on Florida's Gulf coast can see moon rockets launched from Cape Canaveral, 160 miles across the state, and follow them with the naked eye as they rise up and head eastward out over the Atlantic?

On November 8th, Mr. and Mrs. Ralph Davis of Sarasota had seen the exhaust flare of Pioneer II as it cleared the horizon and appeared to climb slowly farther eastward and away from them. They decided to photograph the next lunar rocket attempt and had two cameras ready for this Army shot of December 6, 1958, which left the Cape Canaveral pad at 12:45.2 a.m.



This is the trail of the first stage caught in a 4 x 5 camera with 6.5-inch lens at f/4.7 on Royal Pan. About 2 minutes of the 176.3-second total burning time is shown. At the end (upper right), the rocket appeared to be almost stationary in the sky, and must have been a great distance out over the Atlantic. The inset shows the last few seconds and burn-out of first stage photographed with Questar on Tri-X film in Hexacon camera. Halo is presumed to be due to vapor trail through which we see rocket's exhaust flame. This is the rocket that went up some 65,000 miles.

Questar Now Guarantees to Resolve 0.8 Second on National Bureau of Standards Test Chart

In early November, Mr. Robert R. Hailey, who is an engineer and a recent Questar owner, found an error no one else had noticed in the distances we gave for resolving 0.8 and 0.9 second on the test chart. Naturally our face was red, but we were very lucky to find the error in our favor. At the distance we had given, 40′ 7″, Questars actually were resolving 0.83 second, instead of the 0.9 second of our guarantee.

This permits us to put the test chart 20 inches farther away and thus at the new distance, 42′ 3″, to guarantee each Questar to resolve 0.8 second. The new and correct figures give 48′ 4″ for 0.7 and only 37′ 6″ for 0.9 second, using the smallest pattern. Our thanks to Mr. Hailey, and apologies to all!

On the Complexities of Star Testing

For over a year now, we have been testing Questars for resolving power on the Bureau of Standards chart, and we find it a consistent and critical method. We prove each Questar on the actual sky, too, testing for things that might only be noticed at night outdoors in a falling temperature. By using the test chart in quiet air at short range we create our own perfect seeing and our customers can do the same.

We were led to this method by the difficulty of testing on double stars in the classical method. As we write, it is Christmas Eve, and a little essay we had worked up on this subject has been turned down by the editors as being incorrect on several points. We were trying to list the complexities of the thing as they might appear to a novice, and we certainly failed, among other things, in trying to paraphrase some authorities. So instead of trying to get the gist of an expert's thought across, let's let the expert speak for himself. Let us quote him on the question of his actual experience in the separation of double stars. For in all truth it appears to us that the experts do not agree here. We quote from a document very kindly recommended to us by the editor, a publication of the U. S. Naval Observatory, Second Series, 1956, Volume XVII, Part V, by William Markowitz.

"The resolving power of a telescope for visible light according to the formula of Lord Rayleigh is 5″.03/A, where A is the aperture in inches. According to the formula of Dawes it is 4″.56/A. It is frequently implied that at the separations given by these formulas the components of an equal pair should be seen as definitely separate. The Rayleigh formula expresses the condition that the center of the Airy disk of one component falls on the center of the first dark ring of the other component. Since the intensity of the Airy disk is not zero at a point midway between the center of the disk and the center of the first dark ring it follows that the components should be seen merged rather than separate.

"My experience with the 26-inch confirms this. The formulas of Rayleigh and Dawes give 0″.19 and 0″.18, respectively, as the minimum separation. Stars of such separation were noted as 'notched,' and as we have seen, the measured size of the Airy disk is 0″.22. According to my records pairs were noted as 'in contact' when the measured separation varied from about 0″.20 to 0″.26, the mean being 0″.23. Pairs were noted as 'just separate' when the measured distance varied from about 0″.25 to 0″.28, the mean value being 0″.26.

"Information on the separation of the components at the point of resolution is scant for other telescopes. For the 36-inch Lick refractor, P. Muller refers to 0″.17 as 'the limit of effective separation.' This value corresponds to 0″.23 found above for the 26-inch when the components are in contact.

"It appears, therefore, that the resolution formulas of Rayleigh or Dawes correspond to merged images. Definite separation, viewed as contact, is represented by the formula

$$S = 6''.0/A,$$

where S is the separation at contact."

Crater, Crater, Terminator

The beautiful moon photographs taken with the off-axis 12-inch catadioptric telescope featured on the cover of the December, '58, "Sky and Telescope," seem to us about as fine as any we have ever seen produced by that aperture. The feature picture on page 64 provides us with a wonderful example of the critical illumination that the terminator's region furnishes. Follow, if you will, the terminator shadow in Mare Imbrium, the largest great plain. Note how the floor of the plain is shown clearly rippled, especially between dark-floored crater Plato and Archimedes, above it.

Now compare, if you will, this area with the same area on the facing page. The shadow band has moved almost two days' march to the right, leaving the floor between Plato and Archimedes apparently unwrinkled and flat as a pancake.

By coincidence, our January page carried a Questar photograph of the Mare Imbrium where the angle of illumination falls between those of the two Kutter photographs. It might amuse you to compare the three pictures.

Laurence Braymer
President

QUESTAR CORPORATION
New Hope, Pennsylvania

tioned earlier are adhered to, we seem to be jumping about over the landscape with no particular objective in view or likely to appear. Perhaps the quiz program format has inspired this rather dull technique.

From the standpoint of accuracy and astronomical fact, the book is only fair. Mr. Pickering is not a professionally trained astronomer, nor need he be. However, there are errors of fact that could easily have been avoided. Some reveal that the work is a compilation from the works of others. For example, question 240 perpetuates the error of a recent college text in the discovery date of Pluto, which was actually 1930, not 1931. Question 4 quotes one source on the distance to the sun to the nearest mile! Question 459 gives the fourth power of 2.512 as 36.8, when it is actually 39.8.

A serious misunderstanding of an important subject is revealed by the answer to question 63, concerning whether the sun or the moon has the greater tidal effect upon the earth. Mr. Pickering has read that the sun's tide-raising force is about 5/11 the moon's but has confused this differential effect with the gravitational pull between two bodies. Although gravitational attraction varies as the inverse square of the distance, the tide-raising effect depends on the inverse cube.

It is difficult to find points on which I can recommend this work for SKY AND TELESCOPE readers. Well written but poorly conceived, it will add little to one's knowledge or understanding of astronomy. Its organization prevents it from contributing anything to the reader's perspective.

HARRY E. CRULL
J. I. Holcomb Observatory
Butler University

NEW BOOKS RECEIVED

THE HANDBOOK OF THE BRITISH ASTRONOMICAL ASSOCIATION 1959, *J. G. Porter*, editor, 1958, *British Astronomical Association*, 303 Bath Rd., Hounslow West, Middlesex, England. 60 pages. 5s for members; 9s for nonmembers; paper bound.

This year's edition of the BAA *Handbook* contains the same kind of useful information as last year's. To aid the amateur in planning his observing, there are ephemerides of the sun, moon, planets, periodic comets expected to return in 1959, and a convenient table of the sun's colongitude for lunar observers. Predictions of the phenomena of Jupiter's satellites are given, together with finder charts for the three outermost planets. Detailed information is provided concerning major meteor showers of 1959.

SONNENSTRAHLUNG UND LUFTTRÜBUNG, *Leonhard Foitzik* and *Hans Hinzpeter*, 1958, *Akademische Verlagsgesellschaft*, Sternwartenstrasse 8, Leipzig C 1, East Germany. 309 pages. DM 43.

Solar Radiation and Atmospheric Extinction is a survey account of methods for measuring the sun's radiation at optical wave lengths, and the calculation of the absorbing and scattering effects of the earth's atmosphere. There are discussions of pyrheliometer observations, the solar constant, the ozonosphere, and model atmospheres. This treatise in German is on the level of college students whose major field is astronomy or geophysics. It is volume 31 of the well-known series, Problems of Cosmic Physics.

LET'S GO TO A PLANETARIUM, *Louis Wolfe*, 1958, *Putnam's*. 47 pages. $1.95.

Written for the very young reader, this simple book describes a visit to a large planetarium. Although the author lists only seven major planetariums in the United States, two other large ones are in operation, at Flint, Michigan, and Boston, Massachusetts. And many of the country's smaller installations are well equipped, making trips to them enjoyable and enlightening for people of all ages.

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Select the new '59 *Dynascope* you prefer and send your check or money order today. Or use our liberal easy-payment plan and take months to pay. New *Dynascopes* are also available in 6", 8", 10" and 12" models. Write for full details about these exciting instruments and Criterion's full line of quality accessories.

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NEW! SUPER DELUXE ELECTRIC 4-INCH DYNASCOPE

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• HANDSOME STEEL AND GRAINED-HARDWOOD TRIPOD with special tapered shank ends. Includes spreaders and heavily reinforced joints. No danger of collapse, sideplay or wobble. Sets up quickly anywhere; folds easily and compactly for complete portability.

• EXQUISITE HAND-CORRECTED 4-INCH PARABOLIC MIRROR accurate to better than 1/8 wave. Made of pyrex. Aluminized, overcoated. Triple tested. Mounted in removable cell. • ADVANCED DESIGN EXTRA HEAVY-DUTY EQUATORIAL MOUNT with oversize castings and fingertip control. Adjustable for latitude. Absolutely smooth action. Rotating base for easier orientation. • SETTING CIRCLES for both right ascension and declination assure faster location of specific object. • SLOW MOTION on declination. • 5 SHARP-VIEW EYEPIECES: 18-mm Achromatic Ramsden, 12.7-mm Achromatic Ramsden, 9-mm Achromatic Ramsden, 7-mm Achromatic Ramsden and 6-mm Orthoscopic—for 65X, 100X, 130X, 167X and 220X. All precision threaded, standard 1¼" diameter barrels. • NEW DYN-O-MATIC ELECTRIC DRIVE, with totally enclosed self-acting clutch. • 6 X 30 ACHROMATIC FINDERSCOPE with cross hairs and extra-firm twin post mounting. Micrometer focusing, coated achromatic objective. • FULLY ROTATING BAKELITE TUBE with double-thick wall for maximum strength. Polished rings of pure cast aluminum provide extra reinforcement for ends. Smart grey wrinkle finish.

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NEW! DELUXE ELECTRIC 4-INCH DYNASCOPE

with heavy-duty mount and new Rotating Rings

A truly scientific instrument with all the features of our standard model plus extra advantages for even finer viewing. Larger and heavier mount (weighs over 12 lbs.) is full equatorial. Saddle has felt-lined rotating rings that permit tube to be quickly positioned for accessories or to bring eyepiece into more comfortable viewing position.

• EXQUISITE 4-INCH PARABOLIC PYREX MIRROR accurate to 1/8 wave. For famed Dynascope optical superiority. • NEW DYN-O-MATIC ELECTRIC DRIVE, totally enclosed, with self-acting clutch. • TRUE EQUATORIAL AND ALTAZIMUTH MOUNT with complete friction adjustments for any latitude, declination and ascension. Rugged cast-iron construction. • 3 STANDARD 1¼" EYEPIECES: 18-mm Huygens, 9-mm Achromatic Ramsden, 7-mm Achromatic Ramsden for 65X, 130X and 167X. • 4X ACHROMATIC FINDERSCOPE with crosshairs, micrometer focusing and adjustable collimation. • RACK AND PINION DOUBLE-DRAW EYEPIECE Holder for easy, exact adjustments. Accommodates any eyepiece, negative or positive. • PROFESSIONAL-TYPE STEEL TRIPOD with fast-fold legs for easy portability. Extra stability in vibration-free design.

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NEW! LIGHTWEIGHT ELECTRIC 6-INCH DYNASCOPE

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Construction of a Dall Null Tester

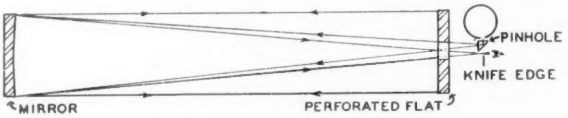
IT IS very probable that few telescope mirrors would be made by amateurs without the aid of the well-known Foucault knife-edge test. When a mirror surface is to be part of a sphere, the Foucault test has great sensitivity at the center of curvature because it is a null test, the mirror surface seeming to darken smoothly all over when the figure is perfect.

Ever since Foucault first published his method in 1859, optical workers have sought to improve the test when applied to aspheric surfaces, such as the standard paraboloid of an astronomical reflector. It is hard to obtain null-test accuracy in the outermost zones of the mirror from an observation of the familiar Foucault patterns, and such tests as the zonal mask method, Everest's "shadow-limit" method, the Ronchi grating method, all require considerable judgment in interpreting the shadow pattern. Mirrors with focal ratios shorter than f/6 are particularly difficult to test because the strong shadow patterns will easily cover small zonal irregularities.

Null testing of paraboloidal mirrors, obtaining the smooth, even shadow pattern of a spherical mirror tested at its center of curvature, is one of the most sensitive and convenient tests devised for the optical worker where 1/10- to 1/20-wave accuracy is sufficient. Here I wish to describe construction of a testing device that any amateur can use.

One method of null testing a paraboloid is to autocollimate it against a master flat, the latter being slightly larger than the mirror under test and with a surface accuracy as good or better than that desired on the finished mirror. Most amateurs of my acquaintance do not have such a flat and are not likely to consider the making of one, which would be more demanding than the mirror itself. As can be seen in Fig. 1, the double reflection off the mirror makes the errors on its surface seem twice as large as they really are, but the test has the disadvantage of being extremely sensitive to alignment.

Fig. 1. The best method for null testing a paraboloid at its focus with an optical flat.



Autocollimating light from a perfect paraboloid slightly larger than the mirror, or from one considerably larger and using a small off-axis section, is possible, but in order to view the surface a kind of Newtonian diagonal must be mounted in the light beam. Heat from the worker's head is also liable to affect the steadiness of the image.

In 1947, the English optical worker Horace E. Dall proposed a method for null testing a paraboloid at its center of curvature (*Journal* of the British Astronomical Association, *57,* 201, November, 1947). The test was revised in 1952 and published in *Amateur Telescope Making — Book Three,* page 149, from which the accompanying graph (Fig. 3) has been taken.

The principle of the test is that a plano-convex lens is placed in front of the pinhole (in the 1952 revised test) and in such a position that the spherical aberration of the lens will just compensate for the paraboloidal aberration (r^2/R) of the mirror. The lens introduces aberrations equal, but opposite in sign, to those by which a sphere and a paraboloid differ, so when the light is returned to the center of curvature it seems to come from a sphere. The mirror must have a paraboloidal figure for this to happen. The eye at the knife-edge sees a surface whose zones all seem to have a common focus and a null test results. Fig. 2 represents the general setup of the parts of the tester.

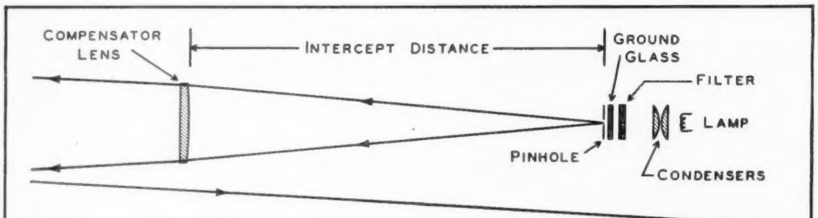


Fig. 2. The arrangement of parts used in testing by Dall's null method. The ratio of focal length of mirror to lens determines the separation of the lens and pinhole.

The important features of the test are:

1. The knife-edge remains fixed at the true center of curvature of the mirror, the correcting lens and pinhole assembly being advanced toward the mirror to obtain the proper cutoff position.

2. The lens and pinhole separation must be correct for the focal length used and should be set to within 1/1,000 inch if the apparatus permits. The separation or intercept distance, **B,** is from the pinhole to the near (convex) vertex of the lens, as the plano side faces the mirror.

3. Glass with a refractive index near 1.52 (C-1 or BSC-2) must be used for the lens, which should be of high quality. War-surplus lenses may not be satisfactory. Bausch and Lomb eyepiece field lenses, however, come in a variety of stock sizes at reasonable cost.

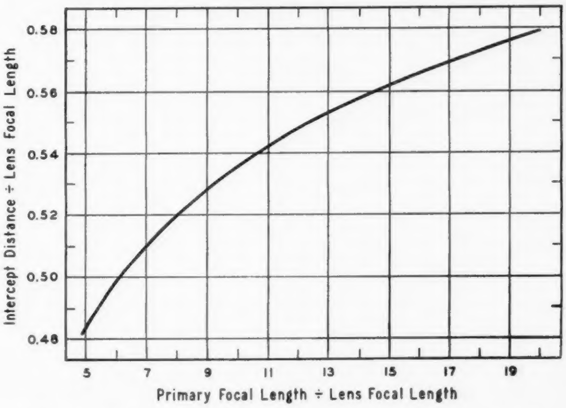


Fig. 3. A graph for determining the length of the spacer rod that is used to place the lens and pinhole at the correct separation. Adapted from "Amateur Telescope Making — Book Three," published by Scientific American, Inc.

4. A lens focal length 1/5 to 1/20 that of the mirror being tested is satisfactory, except that for focal ratios smaller than f/6 the limits are better set at 1/5 to 1/10 the mirror's focal length. An alternative rule with short-focus mirrors is to choose a focal length for the lens equal to half the mirror's diameter.

5. As in any knife-edge test, keep the separation of the pinhole and knife-edge as small as practicable — not more than two per cent of the focal length of the mirror. Otherwise, strong astigmatic shadows may render the test useless.

6. A red filter must be used to eliminate the chromatic aberration of the lens. The graph of Fig. 3 has been calculated for red gelatin.

7. The pinhole must be accurately aligned on the optical axis of the lens, or there will be astigmatic shadows. Similarly, the axis of the lens must be aligned with the center of the mirror to within a degree or two.

Lens-pinhole separation. To find the intercept distance, **B,** first determine **F/f,** which is the focal length of the primary mirror divided by the focal length of the lens. Read along the bottom of the graph (Fig. 3) until this value is found, and find the point on the curve corresponding to it. Then read at the left the value of **B/f,** which is the intercept distance divided by the lens focal length. Next, multiply this by the lens focal length and the intercept distance is determined.

For example, an 8-inch mirror of 48-inch focal length combined with a lens of 4.173-inch focus gives an **F/f** value of 11.5. Going up to the curve and reading the ordinate value gives **B/f** equal to 0.545. The intercept distance is then 4.173×0.545, or 2.274 inches.

Centering the lens. The lens is mounted by the "cup-centering" principle, so that uncentered or poorly centered lenses may be used. The convex surface of the lens rests on an accurately turned ring at the front of the housing tube (Fig. 4), while a ring presses against the flat side of the lens causing its convex side to slip into a centered position. The optical axis would, perhaps, be decentered if the lens were mounted by its edge in an ordinary cell.

Spacing the lens and pinhole. This is done by means of a small rod, of precisely length **B,** mounted in a bushing that slips snugly inside the housing tube. The lens is set in place and the rod pushed into contact with its vertex; then the pinhole-

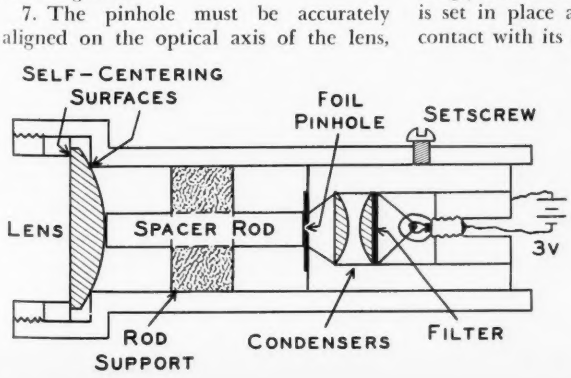


Fig. 4. Constructional details of John Schlauch's tester. A new spacer rod must be made to match the focal length of each mirror under test.

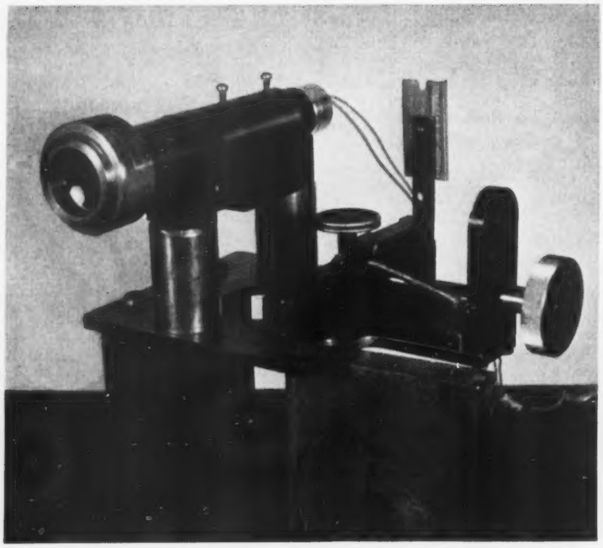


Fig. 5. Old surplus parts were used by Mr. Schlauch in the construction of his tester. This device gives precise results, but much time is needed to align the mirror with the optical axis of the lens.

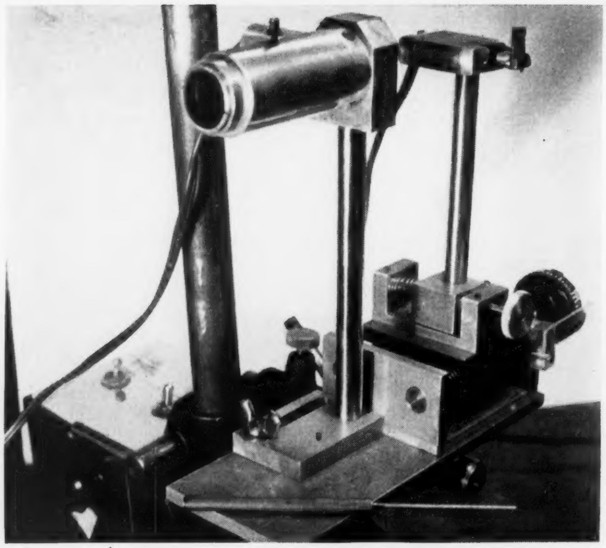


Fig. 6. A more convenient arrangement is that of George T. Keene, providing rotation around and movement along both horizontal and vertical axes of the assembly. All alignment can be done at the tester.

light assembly is pushed forward against the other end of the rod and locked into position with a setscrew. The rod is removed by taking out the lens, which when replaced will be at the proper distance from the pinhole to cancel out the paraboloid's aberrations.

Pinhole, filter, and illumination. Use aluminum foil for the pinhole, making the hole as small as practical for the strength of the light source. If the bulb is bright enough and the filter not too dense, Dall recommends a pinhole between 0.001 and 0.002 inch. The light should be as bright as possible, but in any event a condensing-lens system will probably be required, and it helps provide a cone of light large enough to illuminate fully a short-focus mirror. The filter can be placed on either side of the condensing system, but a gelatin or cemented filter

might suffer heat damage if directly in front of the light source. A ground glass helps provide uniform illumination.

Positioning and alignment. As Fig. 5 shows, the tube assembly in my null tester slides in a V-block so that it may be shifted longitudinally to bring the reflected pinhole image to the knife-edge. Alignment of the lens axis and mirror center requires a centered crosshair over the lens. The image of the crosshair in the mirror as viewed from the knife-edge is carefully centered by adjusting the mirror.

The large knurled knob, located on the rod that is horizontal and perpendicular to the tester's optical axis, is for fine adjustment of the knife-edge to intercept the returning image and to permit delicate shadow interpretations. The other control knob is for making zonal readings by moving the knife-edge toward and away from the mirror; in this manner the worker can determine at any time just how far the correction has progressed and how much remains to be done.

It is wearisome, however, to keep traveling from tester to mirror and back again when the two are being aligned. The tester built by George T. Keene (Fig. 6) incorporates provision for vertical adjustment and rotation of the testing unit itself, so all alignment can be done without touching the mirror. This arrangement is advantageous where a number of persons must use the tester in succession.

With my tester I have figured three 8-inch mirrors and one 10-inch with focal ratios of about f/5. The surface accuracy, especially zonal correction, is much better than I have obtained before, using conventional Foucault methods. The null test shows immediately where glass must be removed, avoiding a long series of zonal knife-edge settings and graph drawing.

It is my opinion that mirrors which are to be used in critical astronomical work, such as lunar and planetary studies, must be made to tighter limits than those recommended by Rayleigh. The null test devised by Dall requires such simple instrumentation that any amateur can use it to produce really first-class mirrors.

JOHN SCHLAUCH
68 Southview Terr.
Rochester 20, N. Y.

SUGGESTIONS FOR DESIGNING THE NULL TESTER

ALTHOUGH the null-testing device made by John Schlauch is quite satisfactory for the individual amateur who has relatively few mirrors to test, setting the intercept distance by means of spacer rods may require too much time in an optical shop where many mirrors are being made simultaneously. The alternative design in the diagram below may be used then, permitting rapid setting of the separation between the null lens and the pinhole to within a thousandth of an inch.

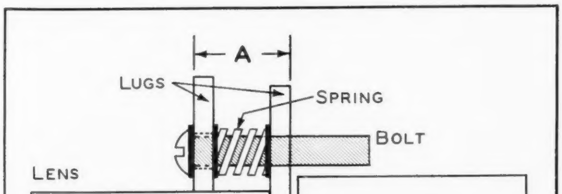
However, for this purpose it is best to use a precision-centered lens, eliminating the self-centering lens holder, which might silhouette part of the test surfaces of very short-focus mirrors. The central thickness of the lens must be very accurately measured with a hand micrometer. (Place the lens between two pieces of cellophane while measuring it, to avoid marking its surface, and subtract the cellophane's thickness from the reading.)

The lens is either held by retaining rings or cemented with its plane surface flush with the end of the larger of two telescoping tubes with thick walls (0.062″). The pinhole is carefully pricked in a thin piece of shim stock or aluminum foil and fastened to the opposite end of the smaller tube, which is supported within the section of the tester that contains the light assembly and condensing lenses.

It is evident from the diagram that the exact separation of lens and pinhole will be set by means of the bolt (10-32) that runs through lugs attached to the tubes, engaging threads in the lug on the smaller tube and carrying a spring with enough tension to avoid slippage. The range of separation for a particular lens is found from the minimum and maximum ordinate values, 0.483 and 0.579, of the graph on page 223, multiplied by the focal length of the lens.

For instance, suppose a lens has a focal length of 4″. The minimum intercept distance will be 1.932″ and the maximum 2.316″, giving a range of 0.384″, within which mirrors of focal ratio from f/4.2 to f/20 can be tested.

However, in locating the lugs on the



A quick-setting Dall null tester. Intercept distance "B" is set by measuring the separation "A." The distance "C" is used only in construction, and depends on the thickness of the lens and its retaining rings, if any. Washers are placed between the ends of the spring and the lug faces for smooth operation.

RANGE OF FOCAL RATIOS WITH DALL NULL TESTER

Test Lens		*Diameter of Mirror Being Tested*				
F.L.	*Aperture*	*4-inch*	*6-inch*	*8-inch*	*10-inch*	*12-inch*
3"	½"	3.8 - 15.0	3.1 - 10.0	3.3 - 7.5	3.4 - 6.0	3.5 - 5.0
4"	½"	5.0 - 20.0	4.2 - 13.3	4.4 - 10.0	4.6 - 8.0	4.7 - 6.7
4"	¾"	5.0 - 20.0	3.3 - 13.3	2.7 - 10.0	2.8 - 8.0	2.9 - 6.7
5"	¾"	6.3 - 25.0	4.2 - 16.7	3.4 - 12.5	3.5 - 10.0	3.6 - 8.3
6"	¾"	7.5 - 30.0	5.0 - 20.0	4.0 - 15.0	4.2 - 12.0	4.3 - 10.0

tubes, the thickness of the lens and the effect of any retaining rings on the measurements must be allowed for. If the lens of 4" focal length has a thickness of 0.1", this must be added to the measured distance from the end of the large tube (flush with the flat side of the lens) and the end of the small tube (carrying the pinhole).

A handy tool for making long measurements to within 0.001" is a vernier caliper. Although many of 6" capacity cost $25 or more, some large mail-order houses list German calipers of slightly smaller capacity for considerably less money.

After setting the tubes to the minimum distance (2.032" in our example), mark the position of the edge of the larger tube on the outside wall of the smaller. Attach a metal lug there, using silver solder or epoxy cement. A similar second lug is fastened to the larger tube after the latter has been pushed tightly against the lug on the smaller tube, which acts as a stop. While the second lug is being fastened, it should be clamped to the first one but separated from it by a piece of metal of exactly known length.

Suitable dimensions for the lugs are 0.125" thick, 0.5" wide, and 0.75" long. If the separator between them is 0.375" long, the total distance from the outside of one lug to the outside of the other will be 0.625" when the larger tube is pulled by the bolt tightly against the lug on the smaller tube. This over-all dimension of 0.625" corresponds to the minimum separation of 1.932" (for a lens 0.1" thick) and to the minimum value of 0.483 on the graph. By means of the bolt, the over-all separation of the lugs may be made $0.625 + 0.384 = 1.009''$, corresponding to the maximum separation of 2.316" for the same lens.

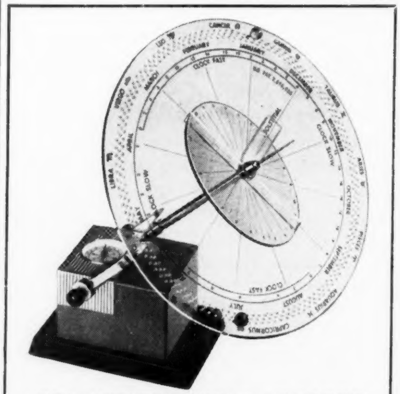
Any setting between these extremes can be quickly made with a screwdriver and either a micrometer or vernier calipers. The measurement can be made over the outside of both lugs (as above) or between them, allowance for their thicknesses being made. With a small minimum lug separation, a 1-inch micrometer can cover all possible cases for certain lenses.

To use the tester, the worker first reads the graph on page 223. As an example, an f/8 6-inch mirror has a focal length of 48 inches. Divide this by 4", the focal length of the tester lens used above, giving an abscissa value of 12 for the graph. The corresponding ordinate is 0.5475, which multiplied by 4" gives 2.190". This required separation is 0.258" greater than the 1.932" minimum distance between the convex lens surface and the pinhole. Adding 0.258" to the over-all lug separation of 0.625" indicates that the lugs are to be adjusted until they are 0.883" apart.

Amateurs with machine-shop experience can further adapt this simple construction by substituting a micrometer spindle in place of the bolt, obtaining direct readings of the separation of lens and pinhole.

It is desirable to keep the tester no larger than is required by the mirrors that are to be tested with it. The null test will operate with any lens within a range of five to 20 times its focal length, 20 to 80 inches for a lens of 4" focus. Dall states, further, that the utilized aperture of the lens is a little more than the intercept distance divided by the f-number of the mirror. This permits construction of the accompanying table indicating the limitations of various lenses selected for use in the null tester.

R. E. C.



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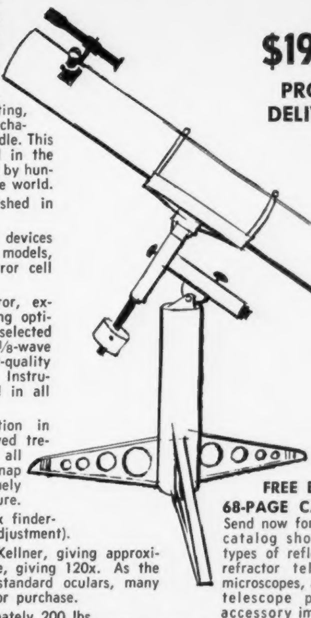

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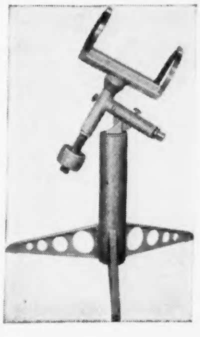

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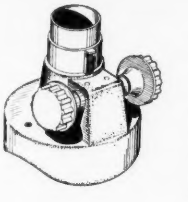

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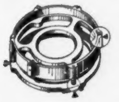

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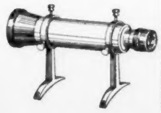

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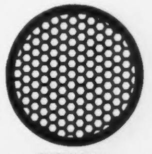

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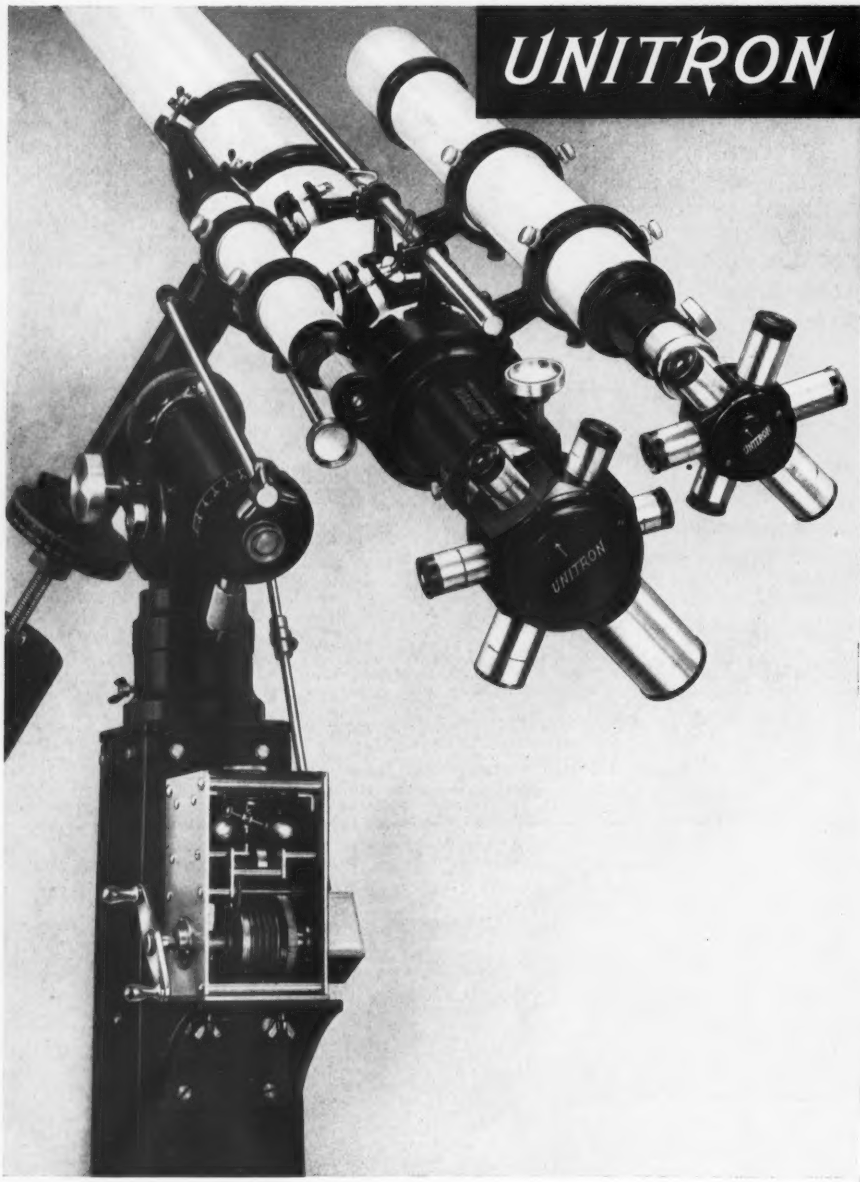
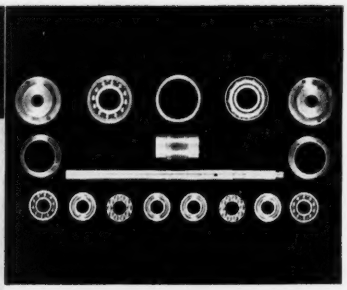
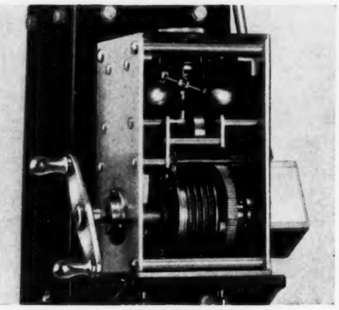




Some of the hidden values



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See the back cover.

Model 166 with metal pier

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

VARIABLE STAR MAXIMA

February 5, RU Sagittarii, 195142, 7.2; 13, R Centauri, **140959**, 5.9; 23, R Sagittarii, 191019, 7.2; 28, V Coronae Borealis, 154639, 7.4.

March 3, T Normae, **153654**, 7.4; 6, T Centauri, 133633, 6.1; 7, S Pictoris, **050848**, 8.0; 8, R Normae, **152849**, 7.2.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

OCCULTATION PREDICTIONS

February 19-20 **Lambda Geminorum** 3.6, 7:15.6 +16-37.0, 12. Im: **A** 22:32.4 −1.2 +0.3 116; **B** 22:33.0 −1.0 +0.8 105.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo − LoS**), and multiply **b** by the difference in latitude (**L − LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A +72°.5,	+42°.5		**E** +91°.0,	+40°.0	
B +73°.6,	+45°.5		**F** +98°.0,	+31°.0	
C +77°.1,	+38°.9		**G** Discontinued		
D +79°.4,	+43°.7		**H** +120°.0,	+36°.0	
I +123°.1,	+49°.5				

MINIMA OF ALGOL

February 1, 7:50; 4, 4:39; 7, 1:28; 9, 22:18; 12, 19:07; 15, 15:56; 18, 12:46; 21, 9:35; 24, 6:24; 27, 3:14.

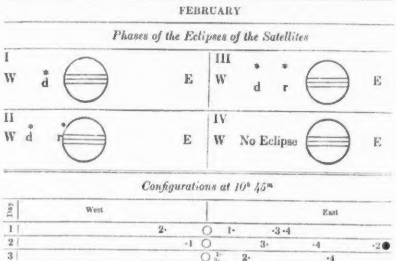
March 2, 0:03; 4, 20:52; 7, 17:41.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

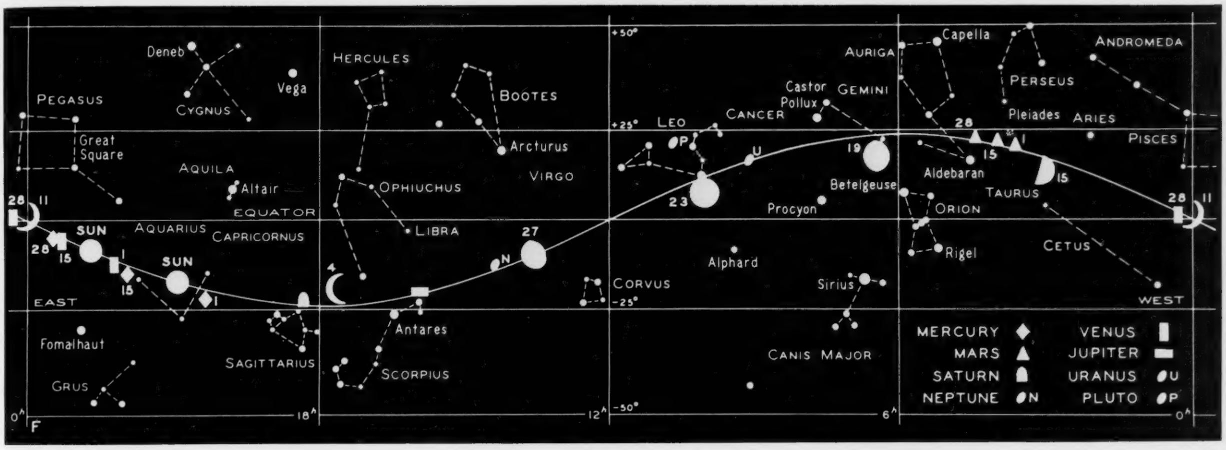
In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac.*



MINOR PLANET PREDICTIONS

Chaldaea, 313, 9.2. February 1, 10:43.7 −3-13; 11, 10:38.9 −1-48; 21, 10:32.2 +0-09. March 3, 10:24.9 +2-24; 13, 10:18.5 +4-43; 23, 10:14.1 +6-51. Opposition on February 25.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

Mercury comes to superior conjunction with the sun on February 14th, and so is too near it to be seen until the end of the month. It will then set about an hour after the sun.

Venus is a brilliant evening object this month. On the 15th it is in Aquarius, at magnitude -3.3, setting in the southwest about two hours after the sun. In a telescope, the planet's nearly full disk is $11''$ in diameter. On the 9th of February the moon will pass about 4° north of Venus, conjunction occurring about 18^h Universal time.

Mars is at eastern quadrature on the 26th, crossing the meridian at about sunset, and appearing as a $+0.8$-magnitude object in Taurus. Telescopically, its disk is then only $7''.4$ in diameter and is noticeably gibbous — 89.4-per-cent illuminated. The moon will be near Mars on the evening of February 15th.

Jupiter reaches western quadrature on the 20th, when it will rise about an hour after midnight, local time, and be seen as a prominent object of magnitude -1.6 near the Libra-Scorpius border. On that date, Jupiter's slightly flattened disk has a $37''.1$ in equatorial diameter and $34''.6$ in polar. The moon will pass about $2\frac{1}{2}°$ north of the giant planet on February 2nd, with conjunction about 1^h UT.

Saturn in midmonth rises about three hours before the sun, and can be seen low in the southeast at dawn. Of magnitude $+0.8$, it is in Sagittarius. Its disk is $14''.0$ in polar diameter; the extent of the ring system is $35''.2$. The moon will pass 4° north of Saturn on the morning of February 4th.

Uranus comes to opposition with the sun on the 3rd, 1.6 billion miles from the earth; at this time it rises about sunset and remains visible all night as a 6th-magnitude object in Cancer. On the 15th it is at right ascension 9^h $05^m.5$, declination $+17°$ $24'$ (1950 co-ordinates), and in a telescope shows a greenish disk $3''.9$ in diameter.

Neptune is an 8th-magnitude planet near the Virgo-Libra border on the 15th of February, at 14^h $20^m.3$, $-12°$ $06'$. On the 8th it will be stationary in right ascension, beginning retrograde (westward) motion among the stars. Telescopically, the planet has a small disk $2''.4$ in diameter.

Pluto will be in opposition to the sun on the 22nd of this month, three billion miles from the earth. At that time the 15th-magnitude planet is in Leo, at 10^h $38^m.1$, $+21°$ $52'$.

W. H. G.

MOON PHASES AND DISTANCE

New moon	February 7, 19:22
First quarter	February 15, 19:20
Full moon	February 23, 8:54
Last quarter	March 2, 2:54

February	Distance	Diameter
Apogee 14, 14^h	251,300 mi.	29′ 33″
Perigee 26, 10^h	227,300 mi.	32′ 40″
March		
Apogee 14, 9^h	251,800 mi.	29′ 29″

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3¼" diam., 48" F.L. (uncoated) ....**$28.00** 4⅛" diam., 62" F.L. (uncoated) **$60.00**

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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm. (2⅛")	254 mm. (10")	**$12.50**	83 mm. (3¼")	660 mm. (26")	**$28.00**
54 mm. (2⅛")	300 mm. (11.8")	**12.50**	83 mm. (3¼")	711 mm. (28")	**28.00**
54 mm. (2⅛")	330 mm. (13")	**12.50**	83 mm. (3¼")	762 mm. (30")	**28.00**
54 mm. (2⅛")	390 mm. (15.4")	**9.75**	83 mm. (3¼")	876 mm. (34½")	**28.00**
54 mm. (2⅛")	508 mm. (20")	**12.50**	83 mm. (3¼")	1016 mm. (40")	**30.00**
54 mm. (2⅛")	600 mm. (23½")	**12.50**	102 mm. (4")	876 mm. (34½")	**60.00**
54 mm. (2⅛")	762 mm. (30")	**12.50**	108 mm. (4¼")	914 mm. (36")	**60.00**
54 mm. (2⅛")	1016 mm. (40")	**12.50**	110 mm. (4⅜")*	1069 mm. (42-1/16")	**60.00**
54 mm. (2⅛")	1270 mm. (50")	**12.50**	110 mm. (4⅜")	1069 mm. (42-1/16")	**67.00**
78 mm. (3-1/16")	381 mm. (15")	**21.00**	128 mm. (5-1/16")*	628 mm. (24¾")	**75.00**
80 mm. (3⅛")	495 mm. (19½")	**28.00**	128 mm. (5-1/16")	628 mm. (24¾")	**85.00**
81 mm. (3-3/16")	622 mm. (24½")	**22.50**	*Not coated		

● We can supply ALUMINUM TUBING AND CELLS for the lenses above. ●

SPECIAL COATED OBJECTIVE BIG 2⅛" DIAM. — 40" F.L. — $6.00

These achromatic objective lenses are tested and have the same high quality as "Big Lenses" described at left, except they are seconds for slight edge chips or small scratches only. Quality guaranteed.

ONLY $6.00 ppd.

ASTRONOMICAL MIRRORS

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon-monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	**$ 9.75**
Pyrex	4¼"	45"	**13.50**
Pyrex	6"	60"	**25.00**

MIRROR MOUNTS, RACK-AND-PINION ● EYEPIECE MOUNTS, and ALUMINUM ● TUBING are available.

90° RIGHT-ANGLE PRISMS

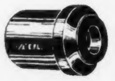
8-mm. face	**$1.00**	———	
12-mm. face	**1.00**	———	
23-mm. face	**1.25**	Silvered	**$2.00**
28-mm. face	**1.75**	Silvered	**2.50**
38-mm. face	**2.00**	Silvered	**2.75**
48-mm. face	**3.00**	Silvered	**4.00**

62-mm. face, coated **$17.50**

TELEVISION PROJECTION LENS

Brand New, f/1.9, E.F.L. 5 inches. Manufactured by Bausch & Lomb. We purchased entire lot of these discontinued units. Five elements, smallest lens 2", largest 4¼". Completely assembled 6" in length. All surfaces hard coated. Get this BARGAIN now.

ONLY $22.50



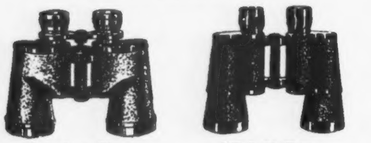
MOUNTED EYEPIECES

The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
6 mm. (¼")	Ramsden	**$ 4.75**
12.5 mm. (½")	Ramsden	**4.50**
12.5 mm. (½")	Symmetrical	**6.00**
16 mm. (⅝")	Erfle (wide-angle)	**12.50**
16 mm. (⅝")	Triplet	**12.50**
18 mm. (¾")	Symmetrical	**6.00**
22 mm. (27/32")	Kellner	**6.00**
27 mm. (1-1/16")	Kellner	**4.50**
32 mm. (1¼")	Orthoscopic	**12.50**
35 mm. (1⅜")	Symmetrical	**8.00**
55 mm. (2-3/16")	Kellner	**6.00**
56 mm. (2¼")	Symmetrical	**6.00**

COATED LENSES 75 cents extra.

COATED BINOCULARS



American Type "Zeiss" Type

Beautiful imported binoculars, precision made, at a low, low price. Above we have pictured the two most popular types. The American Type offers a superior one-piece frame and a clean design, pleasing to the eye. Complete with carrying case and straps. **Price plus 10% Federal tax.**

Size	Field at 1,000 yards	Type	Center Focus	Ind. Focus
6 x 15	360 ft.	Opera	—	**$12.75**
6 x 30	395	Zeiss	**$18.75**	**16.75**
7 x 35	341	Zeiss	**20.75**	**17.95**
7 x 35	341	American	**23.50**	—
7 x 35	578	American Wide Angle 11°	**35.00**	—
7 x 50	372	Zeiss	**24.95**	**22.50**
7 x 50	372	American	**32.50**	—
8 x 30	393	Zeiss	**21.00**	**18.25**
10 x 50	275	Zeiss	**28.75**	**26.75**
20 x 50	183	Zeiss	**33.75**	**31.75**

MONOCULARS

Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
6 x 30	**$10.00**	7 x 50	**$14.75**
8 x 30	**11.25**	16 x 50	**17.50**
7 x 35	**12.50**	20 x 50	**20.00**

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

NEW! 6" LENSES

Our 6" objective will not need high-pressure salesmanship. Its sparkling performance speaks for itself. Test one, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee.

6" DIAM. AIR-SPACED TELESCOPE OBJECTIVE

Hard coated on 4 surfaces

f/10 - 60" focal length { MOUNTED ....**$175.00** / UNMOUNTED .. **150.00**

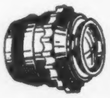
f/15 - 90" focal length { MOUNTED .... **175.00** / UNMOUNTED .. **150.00**

We can supply ALUMINUM TUBING for the lenses above.

"GIANT" WIDE-ANGLE EYEPIECES

ERFLE EYEPIECE (65° field) contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Will make an excellent 35-mm. Kodachrome Viewer. Magnifies seven times .... **$12.50 ppd.**

Same as above without diopter scale **$9.95**

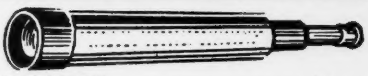


WIDE-ANGLE ERFLE (68° field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1-13/16" aperture **$13.50**

WIDE-ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field **$12.50**

1¼" Diam. Adapter for Erfle eyepieces **$3.95**

GIANT "3" inch TELESCOPE



40 POWER postpaid **$57.50**

HIGH-POWER SPOTTING SCOPE — American Made. Big 3"-diameter achromatic coated objective will give bright crystal-clear images. Micrometer spiral focusing drawtube. Lightweight aluminum construction throughout, black crackle finish, length open 22", closed 15½". Upright image. Guaranteed to give superb performance.

8-POWER ELBOW TELESCOPE

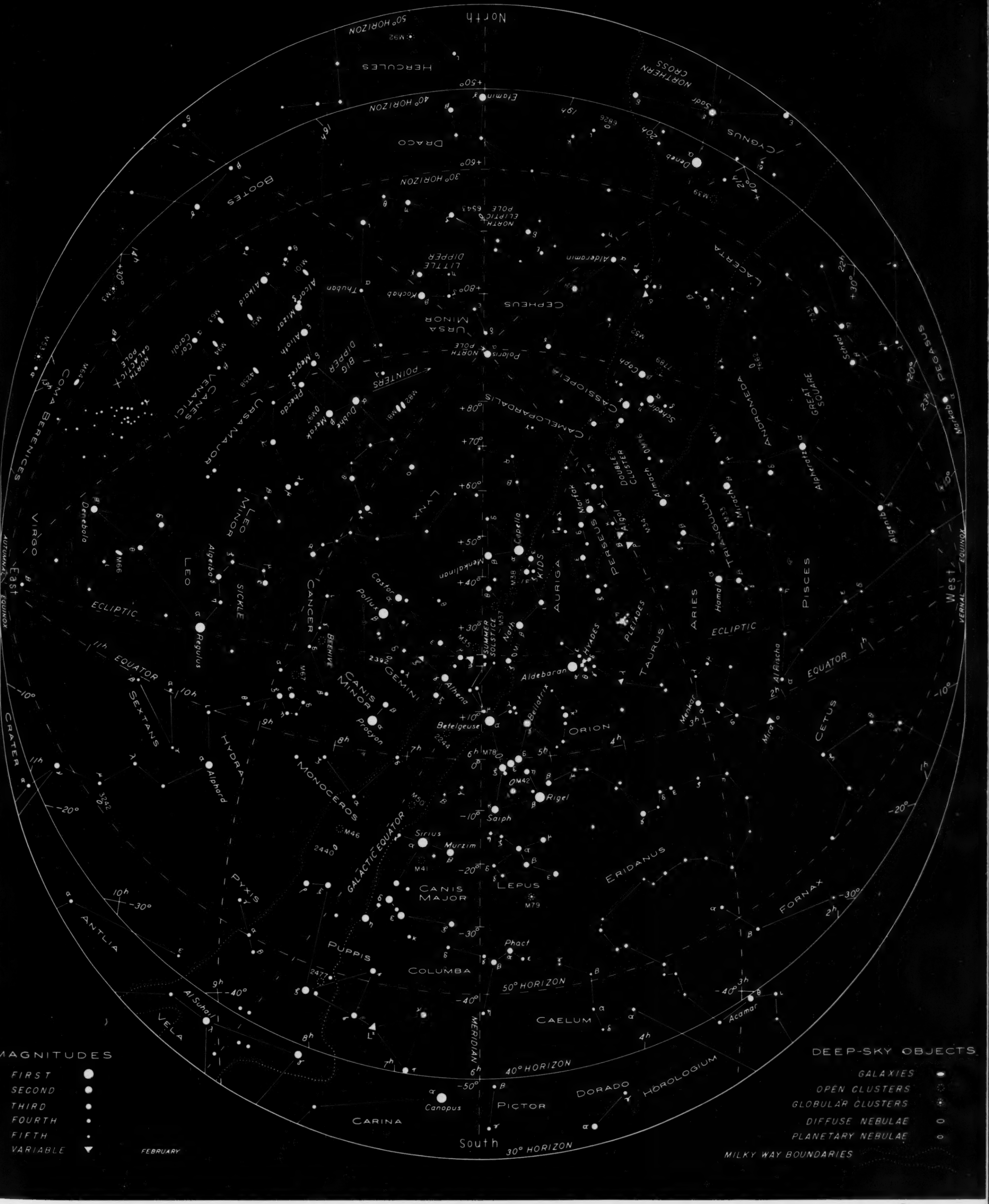
This M-17 telescope has a brilliant-image 48° apparent field — 325 feet at 1,000 yards. The telescope can be adjusted for focusing 15 feet to infinity. It has a 2" objective, focusing eyepiece 28-mm. focal length with an Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

8 x 50

BARGAIN PRICE .... $13.50 ppd.

A. JAEGERS

691S Merrick Road LYNBROOK, N. Y.



©

STARS FOR FEBRUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 21st of February, respectively; also, at 7 p.m. and 6 p.m. on March 7th and 23rd. For other dates, add or subtract ½ hour per week.

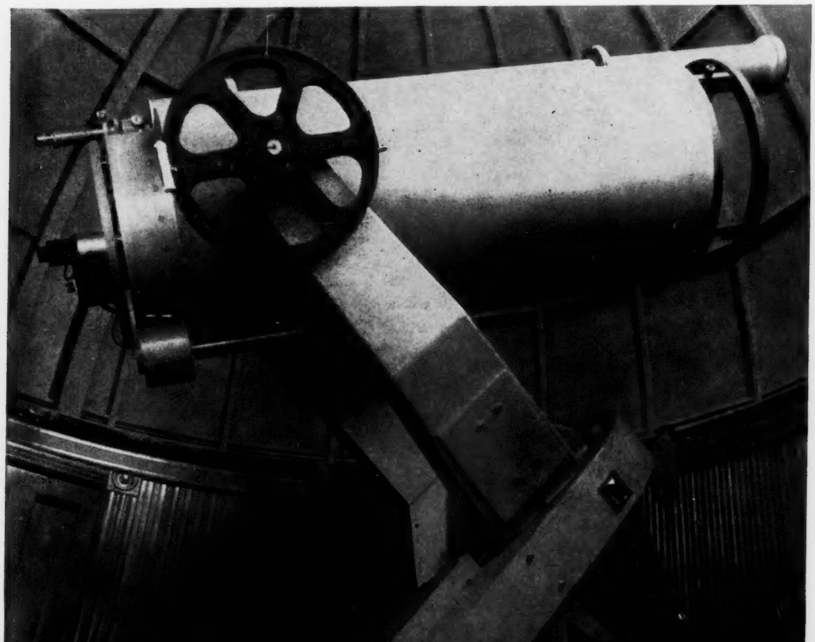
When facing north, hold "North" at the bottom; turn the chart accordingly for other directions. The equator, ecliptic, galactic equator, and meridian are indicated by dashed curves, as are the hour circles that are three and six hours east and west of the meridian.

PRECISION ENGINEERING AND DESIGN

by two famous astronomical manufacturers

Above: A standard, motor-driven Astro-Dome constructed of structural steel.

Below: A typical Tinsley telescope built to meet professional observing requirements.



The technical skill of Astro-Dome, Inc., and Tinsley Laboratories guarantees the highest standards of precision in observatory domes and telescopes.

ASTRO-DOME is proud to have been selected to design and build the domes at the University of Wisconsin's beautiful Pine Bluff Observatory. As a visitor to the observatory travels over the rolling hills of southern Wisconsin, he first catches the gleam of sunlight from the domes of the 36-inch reflector and the 12-inch reflector (pictured here). On arriving at the site he is immediately impressed by the combination of flowing beauty in metal and great structural stability that are features of all Astro-Domes. But only by using these domes for routine observation, night after night, can one really become aware of the ease of operation and the long-wearing qualities of our design. We are now in the process of refining these designs even further to make our domes the best available anywhere. May we assist you with your observatory housing problems, too?

TINSLEY LABORATORIES has engineered the 20-inch fork-mounted Newtonian-Cassegrainian reflector pictured here for the Students' Observatory at the University of California. Note the clean functional design of the mounting, planned for efficient observing. The optics are of Tinsley precision, all surfaces polished to 1/10-wave accuracy. Small and large telescopes of any design are available to your exacting specifications — you are invited to request information of any kind that would be useful to you.

Astro-Dome and Tinsley Laboratories now make possible a complete observatory, from telescope to housing, at a cost that will be pleasantly reasonable. Write either company for details, which will be furnished without obligation.

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★

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See pages 228 and 229.